SAA09CR00-001

July 1998

SYSTEM ASSURANCE ANALYSIS

OF THE

10 & 15 TON BRIDGE CRANES

AT THE

SSMEPF

Baseline No.: 036.00

PMN: H70-1528
H70-1529

United Space Alliance

GROUND OPERATIONS

Revision Log

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New	Basic issue	July 6, 1998

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1 SYSTEM ASSURANCE ANALYSIS SUMMARY

1.1 FINDINGS

Table 1. **Findings Summary**

	Assessment	
Reliability Criticality	Critical	
Safety Criticality	Critical	
	Type	**Quantity**
Critical Items	1	2
	1S	-
	2	-
1R Non-CIL Items	1R	6
Critical Flexhoses	1S	-
	2	-
Critical Orifices	1S	-
	2	-
Critical Filters	1S	-
	2	-
Hazard Reports	Accepted Risk	-
	Controlled	1

1.2 AREAS OF CONCERN

The following Areas of Concern were identified with this system:

a. The cranes do not comply with NSS/GO 1740.9 paragraph 201.g.6 (The electrical system shall be designed fail safe……).

2 SYSTEM DESCRIPTION

Electrically operated Demag 10 Ton (PMN H70-1528) and 15 Ton (PMN H70-1529) bridge cranes are mounted on rails inside of the SSME Processing Facility . The 15 ton crane is used to position the SSME on and off dollies for processing in the engine drying area. The 10 ton crane is used to lift and lower the SSME to and from the work stands. Ref. Drawing 387 447 49 (10 Ton) and 387 446 49 (15 Ton)

3 ANALYSIS GROUNDRULES

This analysis has been developed in accordance with NSTS 22206 and NSTS 22254.

The following additional groundrules and assumptions were used during this analysis:

a. Failure of the geardrive system while the load is in close proximity to another object renders the overspeed system ineffective and may result in damage to flight hardware. However, KSC-5400-4526 "Risk Assessment Of Failure Effects Resulting From An Overspeed Trip" concludes that the probability of geardrive failure during that very limited period of the lift in which a failure would render the overspeed system ineffective is so highly remote that it will

not be considered credible. Therefore, per NSTS 22206 paragraph 4.4.1.a.2, this failure mode will not be considered critical category 2.

4 FAILURE MODES AND EFFECTS ANALYSIS

4.1 CRITICALITY ASSESSMENT

Table 2. **Criticality Assessment Worksheet - H70-1528, H70-1529**

System/Subsystem: 10 & 15 Ton Bridge Cranes
Location: SSMEPF
Baseline Number: 036.00

Input / Output	Function	Time Period	Effect of Loss/Failure If Function Fails to Operate or Cease Operation on Time, Fails During Operation, and/or Prematurely Operates	Crit / Noncrit	Notes
Input Electric Power 480 VAC 60 HZ 3 Phase	Supplies power to operate controls, motors, and brakes for hoist, trolley, and bridge.	During crane operations	Failure to operate on time or failure during operation would result in loss of ability to operate the crane.	NC	See SAA 09EL23-003
Operator controls	The operator provides control for operating crane and handling load.	During crane operations	Failure to cease operation on time would result in collision between load and an obstruction possibly leading to loss/damage to a vehicle system.	C	Human error required. See hazard analysis.
Structural support	Provides static foundation to support crane.	At all times	Loss of support for crane during operation would result in personnel injury/loss of life and/or loss/damage to a vehicle system.	C	BOC responsibility
Output Force/Motion Up/Down (Hoist)	Raise/lower and position load.	As required	Failure to operate on time, cease operation on time and failure during operation could result in the load continuing to move in an unspecified direction resulting in personnel injury/loss of life and/or loss (damage) to a vehicle system.	C	See FMEA
North/South (Bridge)	Position flight hardware.	As required	Failure to operate on time, cease operation on time and failure during operation would result in the load continuing to move in an unspecified direction resulting in damage to a vehicle system.	C	See FMEA
East/west (Trolley)	Position flight hardware.	As required	Failure to operate on time, cease operation on time and failure during operation would result in the load continuing to move in an unspecified direction resulting in damage to a vehicle system.	C	See FMEA
Hold Load/Stop (Hoist)	Stop and hold load in fixed position.	As required	Failure of the crane due to abnormal motion could result in personnel injury/loss of life and/or loss (damage) to a vehicle system.	C	See FMEA See groundrule 3.a

4.2 FMEA WORKSHEETS

The Failure Modes and Effects Analysis follows.

The following components were considered passive in the analysis:

Hook
Wire rope
Rails
Steel structure
Wheels

Table 3. **Mechanical FMEA - Hoist**

System/Subsystem: 10 & 15 Ton Bridge Cranes / Hoist
PMN: H70-1528, H70-1529

Drawing No.:387-447-49 & 387-446-49
Reference Figure: None

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
None 407 638 44	Load Hold/Halt Drum Brake	Provides retarding torque to hold load when no power is being transmitted if the load moves down after stopping. Electrically released brake assembly applies load holding torque directly to hoist drum. At overspeed this device will set mechanically to stop the load.	a. Fails to engage. b. Damaged or broken gear teeth/pawl mechanism, solenoid or improper adjustment. c. 09CR00-001.001 d. Visual e. None f. Immediate g. NA	Loss of torque to hold load. Motor brake provides primary torque to hold load.	No effect. Subsequent failure of the motor brake would cause the load to drop. Possible loss of life.	1R
			Fails to release	Load can raise .Lowering can drive through the brake, lowering overload can occur. Possible to wear out brake pad.	No effect.	3
None AFM 06	Gearbox	Transmits power from the hoist motor to the hoist drum.	a. Gear disengagement b. Damaged or broken gear teeth c. 09CR00-001.004 d. Visual e. None f. 1 second g. 3 seconds	Loss of torque to hold the load. Load hold/halt drum brake provides primary holding capability. See groundrule 3.a.	No effect. Subsequent failure of the load hold/halt drum brake would cause the load to drop. Possible loss of life.	1R
None None	Coupling	Transmits power from the hoist motor to the hoist gearbox.	a. Disengagement	Triple failure of motor brake, gearbox and load hold/halt brake required for loss of life.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
None KLA 160 A4	Motor Brake	Provides retarding torque to hold load when no power is being transmitted. Electrically released disc brake is normally set by spring compression to apply load holding torque to motor shaft.	a. Fails to engage b. Brake pad wear/improper adjustment. c. 09CR00-001.002 d. Visual e. None f. seconds g. NA	Loss of torque to hold load. Load Hold/Halt drum brake provides redundant torque to hold load.	No effect. Subsequent failure of the Hold/Halt drum brake would cause the load to drop. Possible loss of life or vehicle.	1R
			Fails to release	Motor assembly can power through the brake, possible damage to GSE.	No effect.	3

Table 4. **Mechanical FMEA - Trolley**

System/Subsystem: 10 & 15 Ton Bridge Cranes / Trolley
PMN: H70-1528, H70-1529

Drawing No.: 387-447-49 & 387-446-49
Reference Figure: 1

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
None None	Gearbox	Transmits power from the trolley motor to the trolley wheel.	Gear disengagement	Loss of torque to move trolley assembly. Weight of assembly/friction or mechanical stops will stop trolley unit.	No effect.	3
None None	Motor brake	Provides retarding torque to hold trolley in place. Electrically released brake applies torque to motor shaft when brake is spring set.	Fails to engage	Loss of torque to stop trolley assembly. Releasing control button removes power and weight of assembly/friction or mechanical stops will stop trolley unit.	No effect.	3
			Fails to release	Trolley assembly can power through the brake, possible damage to GSE.	No effect.	3

figureTable 5. **Mechanical FMEA - Bridge**

System/Subsystem: 10 & 15 Ton Bridge Cranes / Bridge
PMN: H70-1528, H70-1529

Drawing No.:387-447-49 & 387-446-49
Reference Figure: 1

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
None None	Gearbox	Transmits power from the bridge motor to the bridge drive shaft/wheels.	Gear disengagement	Loss of torque to move bridge assembly. Weight of assembly, friction or mechanical stops will stop bridge unit.	No effect.	3
None None	Motor brake	Provides retarding torque to hold bridge in place. Electrically released brake applies torque to motor shaft when brake is spring set. Two motors and brakes are provided.	One brake fails to engage	Loss of torque to stop bridge unit. Releasing control lever removes power and weight of assemblies/friction or mechanical stops will stop bridge unit.	No effect.	3
			One brake fails to release	Bridge unit can power through the brake, possible damage to GSE..	No effect.	3

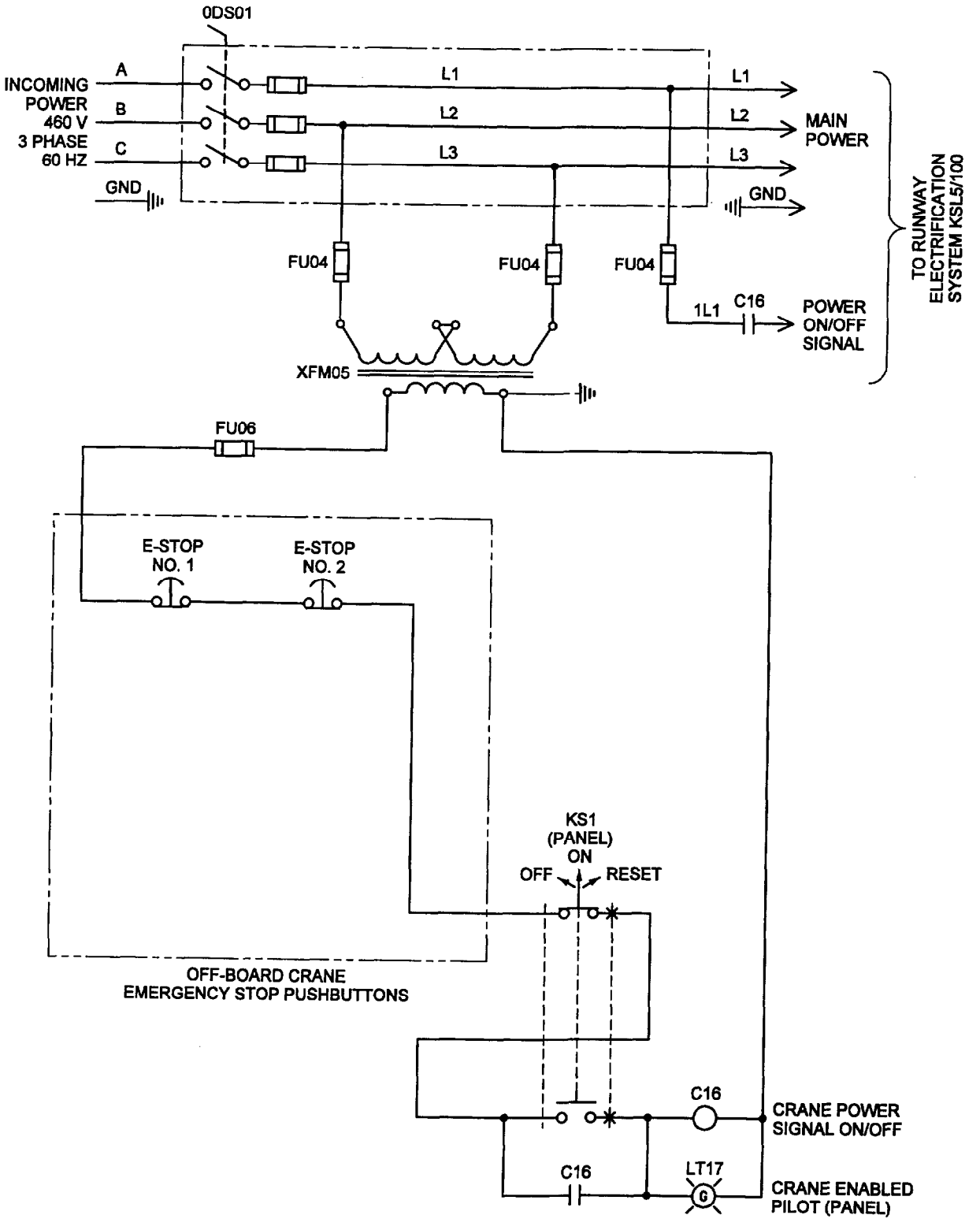


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 1 OF 11)

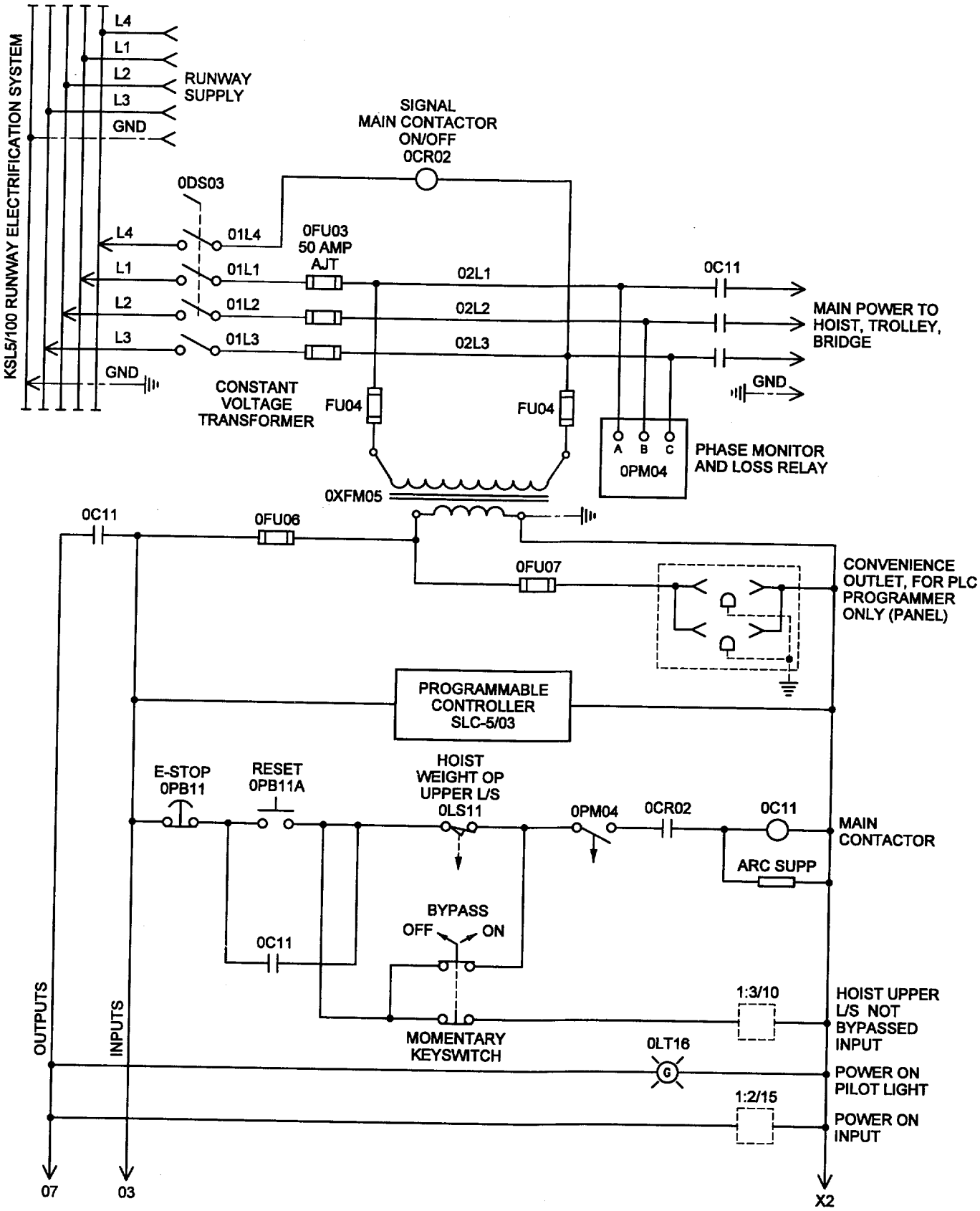


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 2 OF 11)

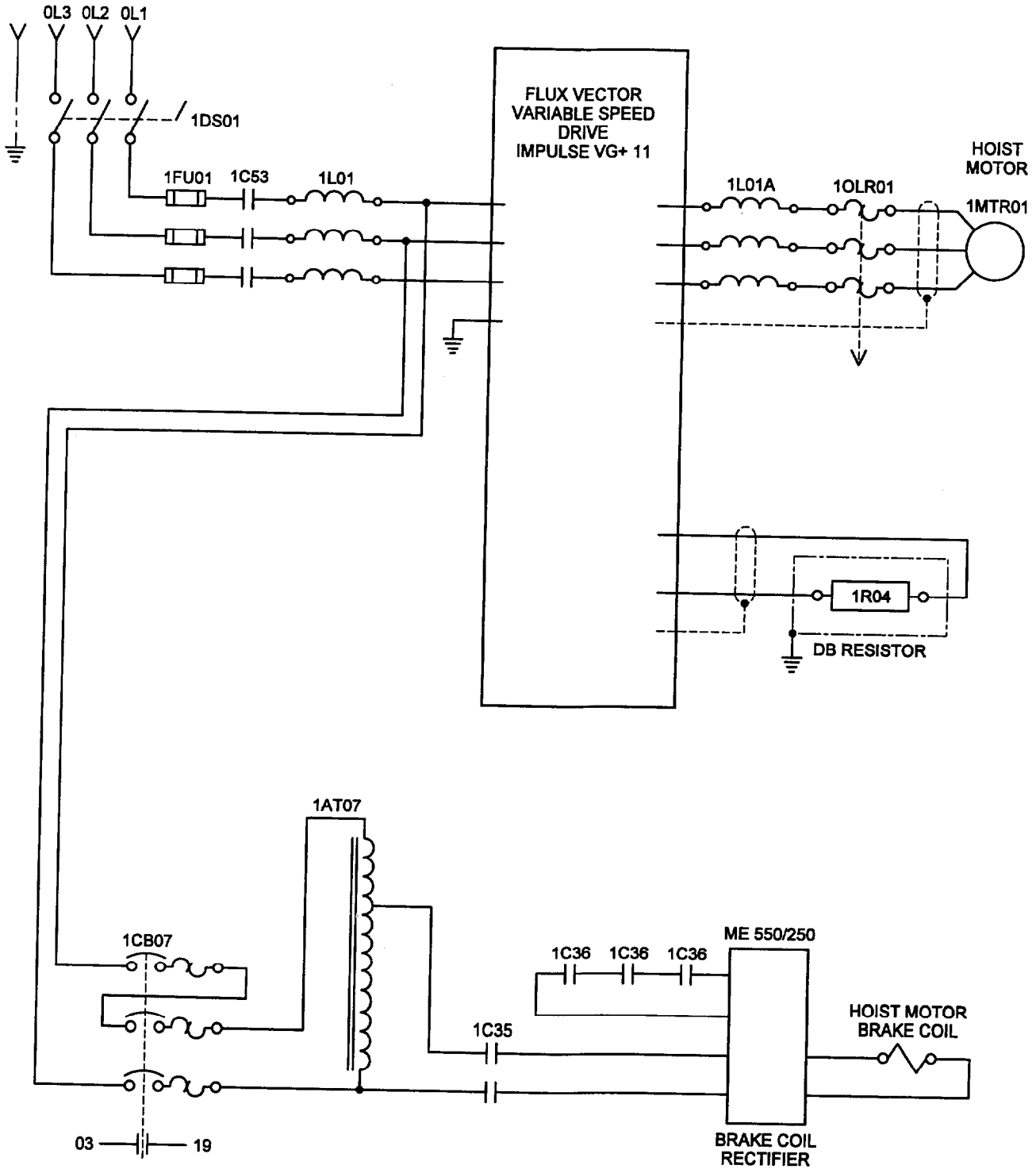


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 3 OF 11)

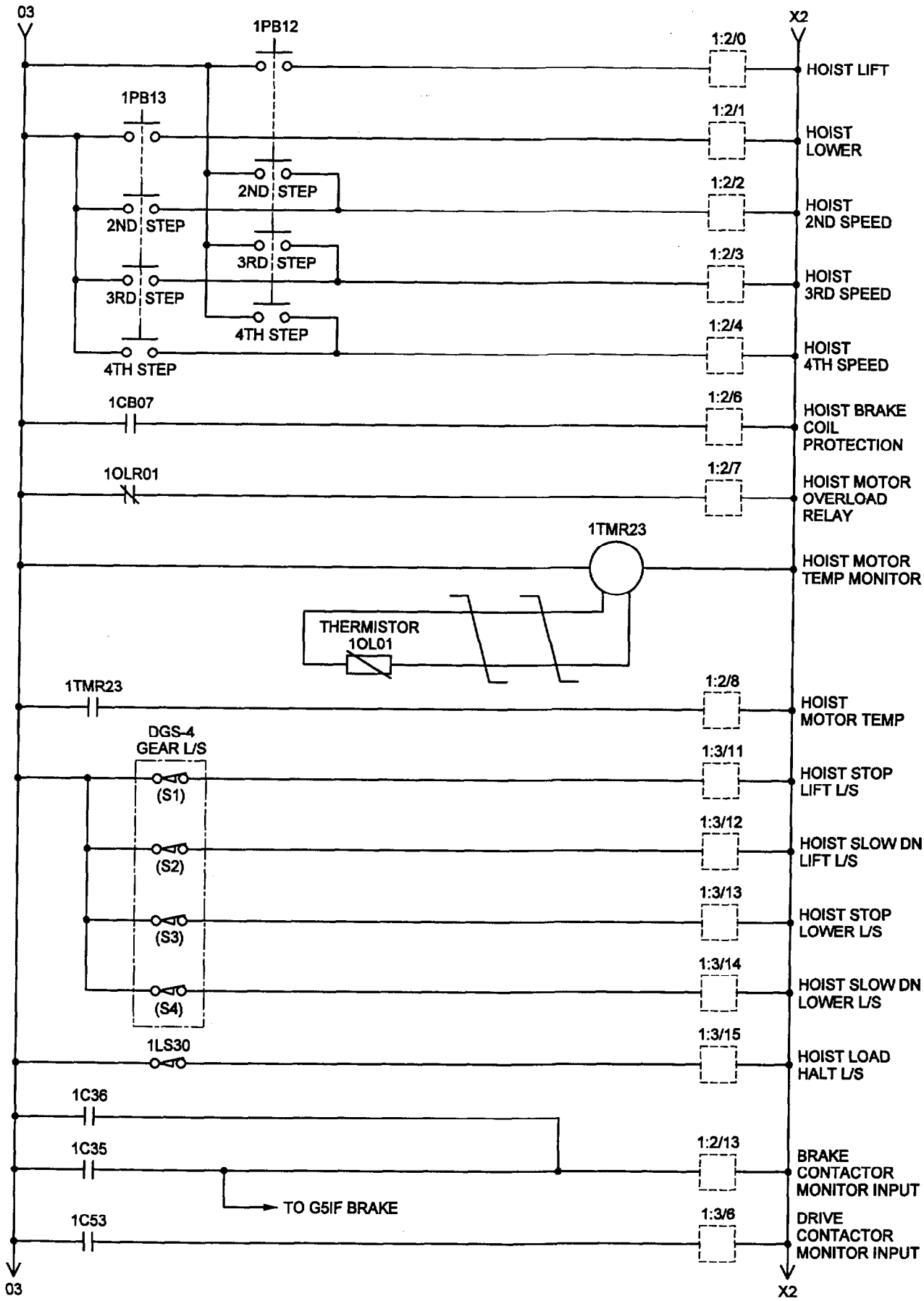


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 4 OF 11)

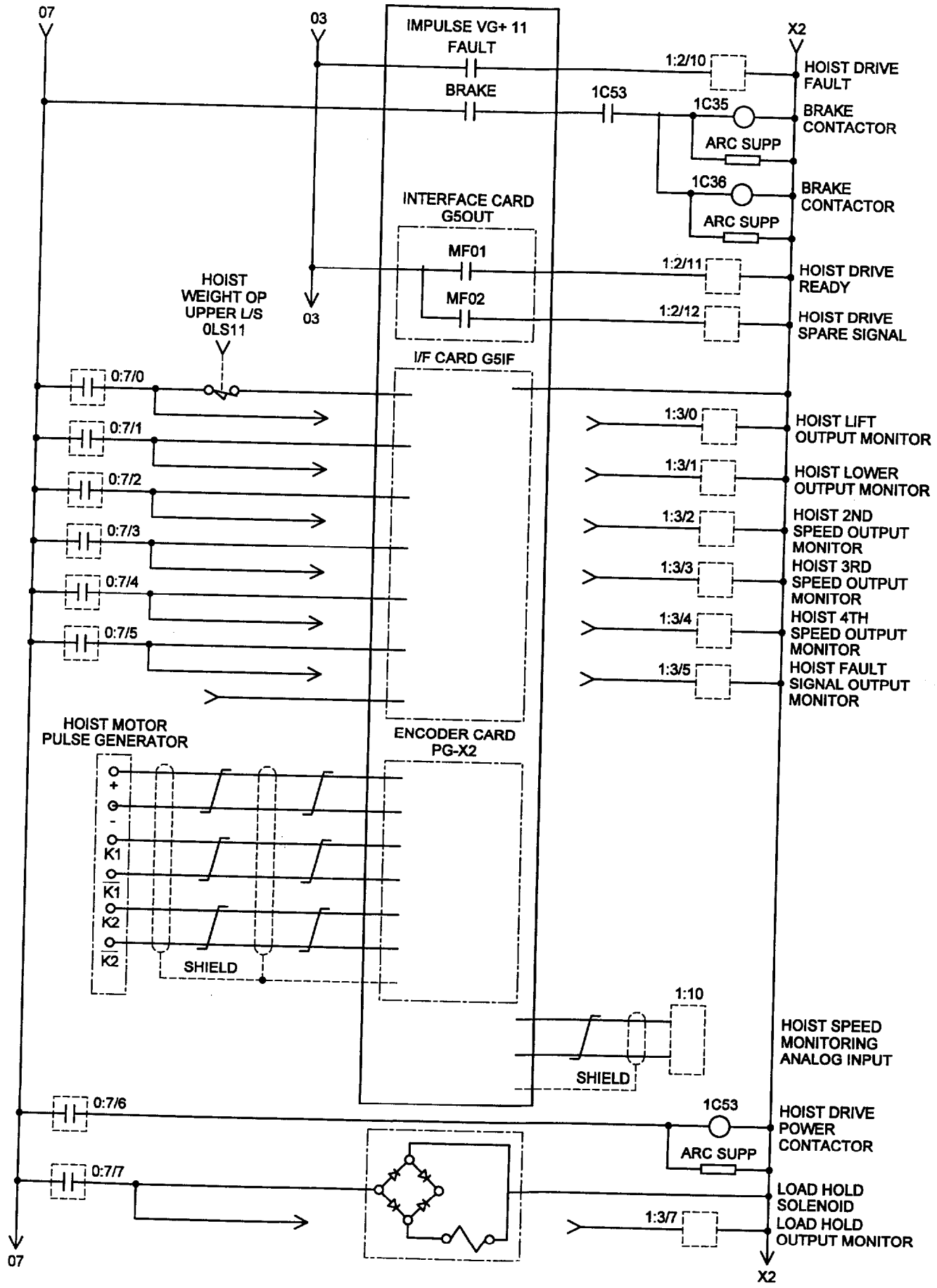


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 5 OF 11)

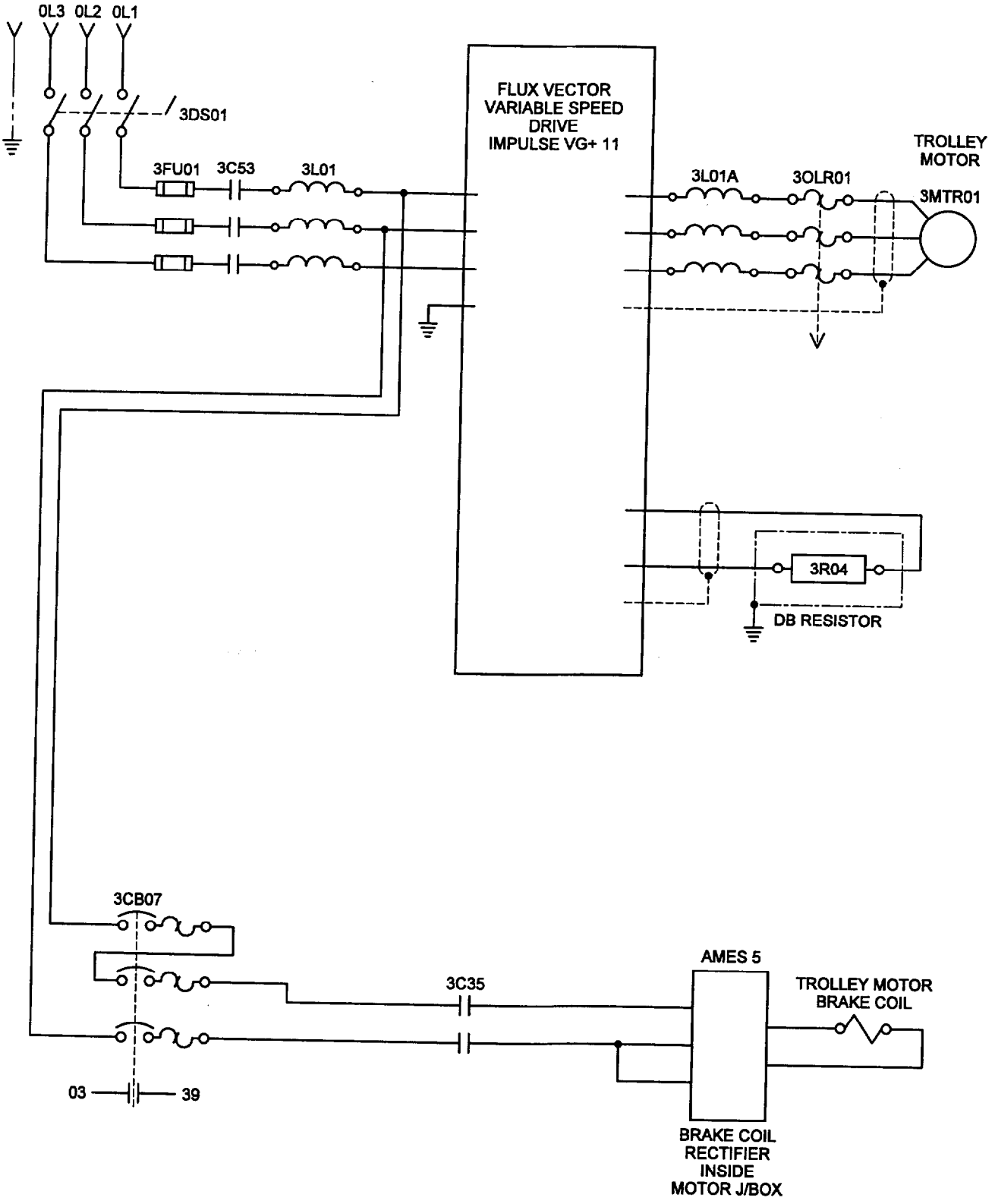


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 6 OF 11)

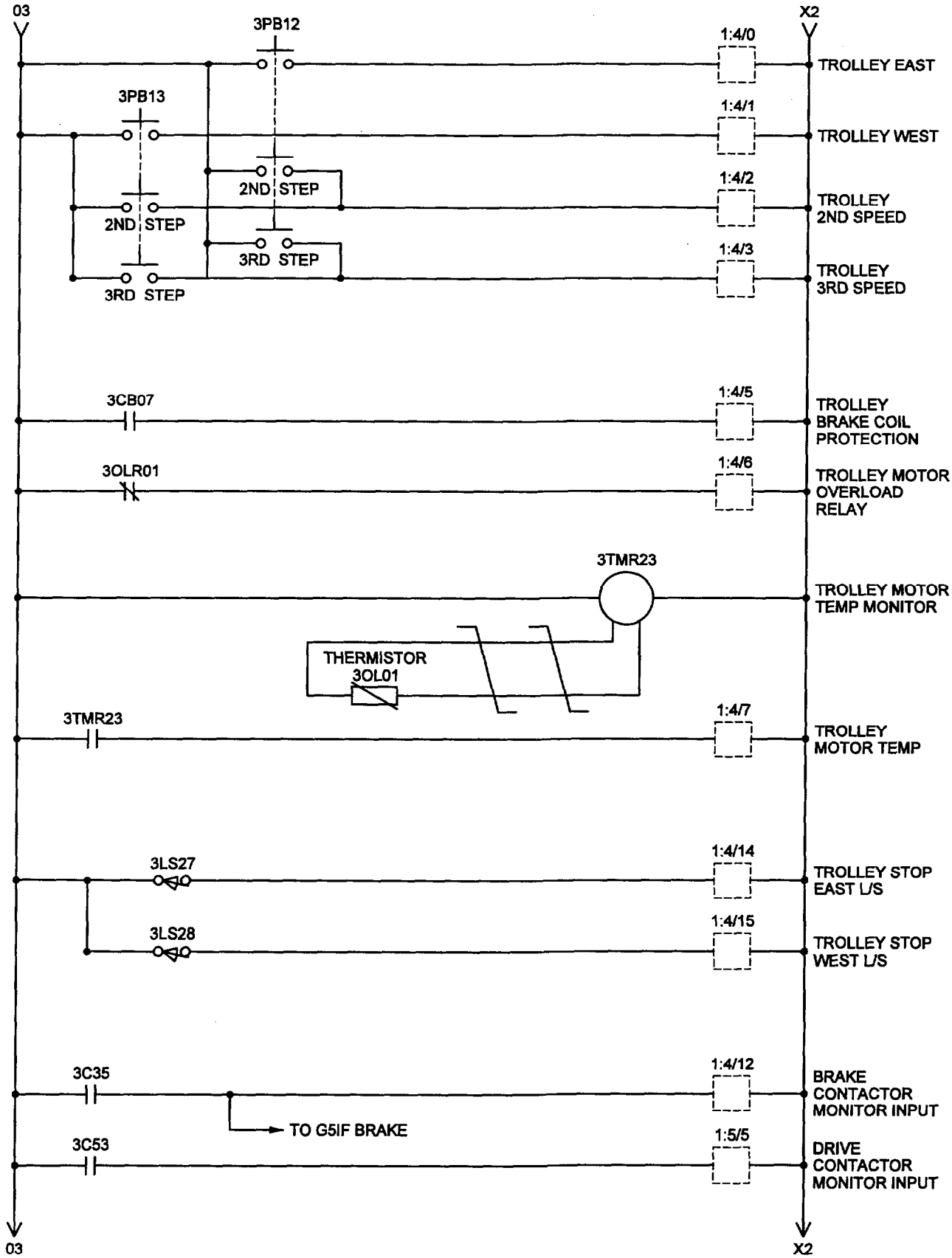


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 7 OF 11)

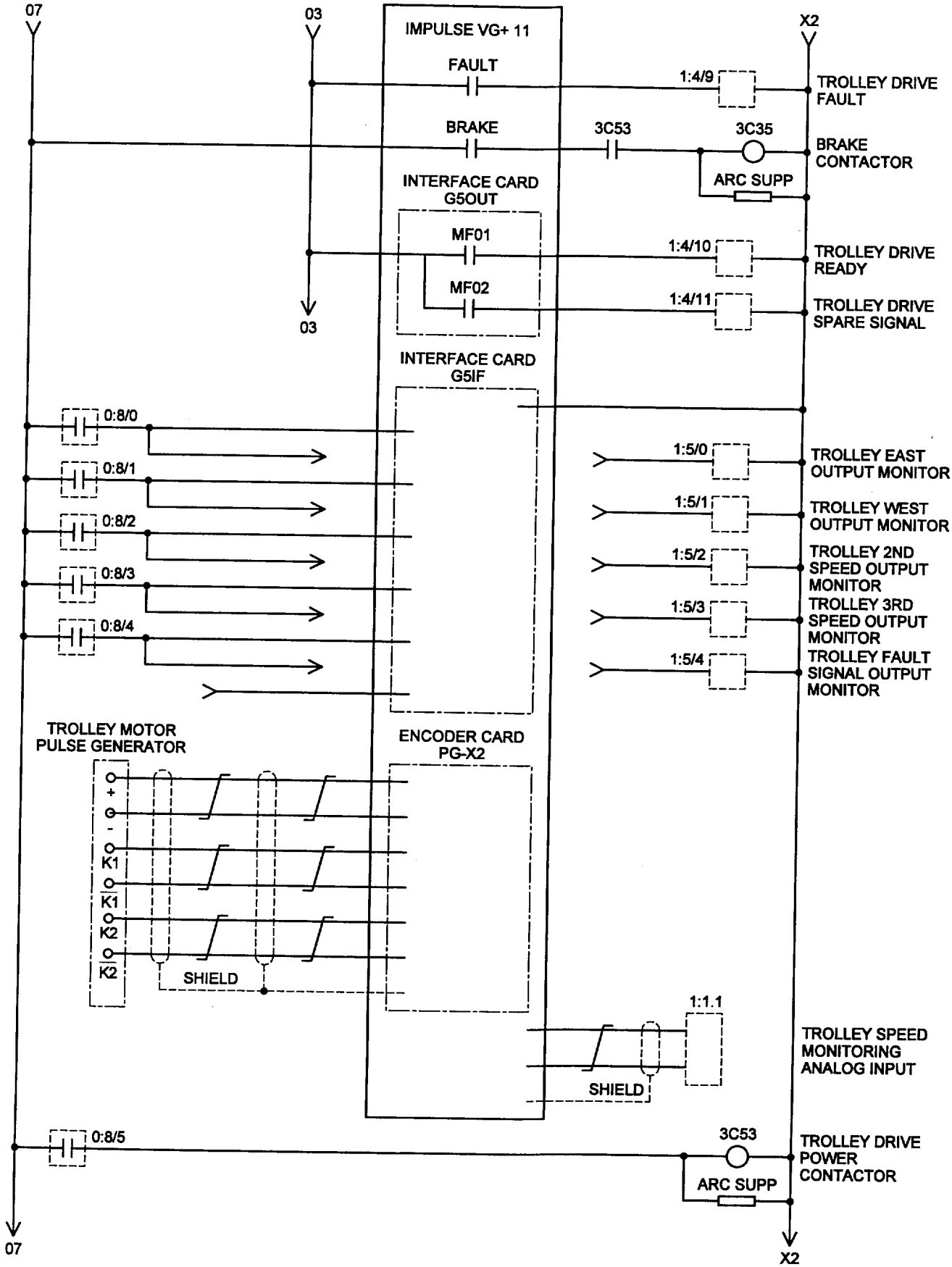


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 8 OF 11)

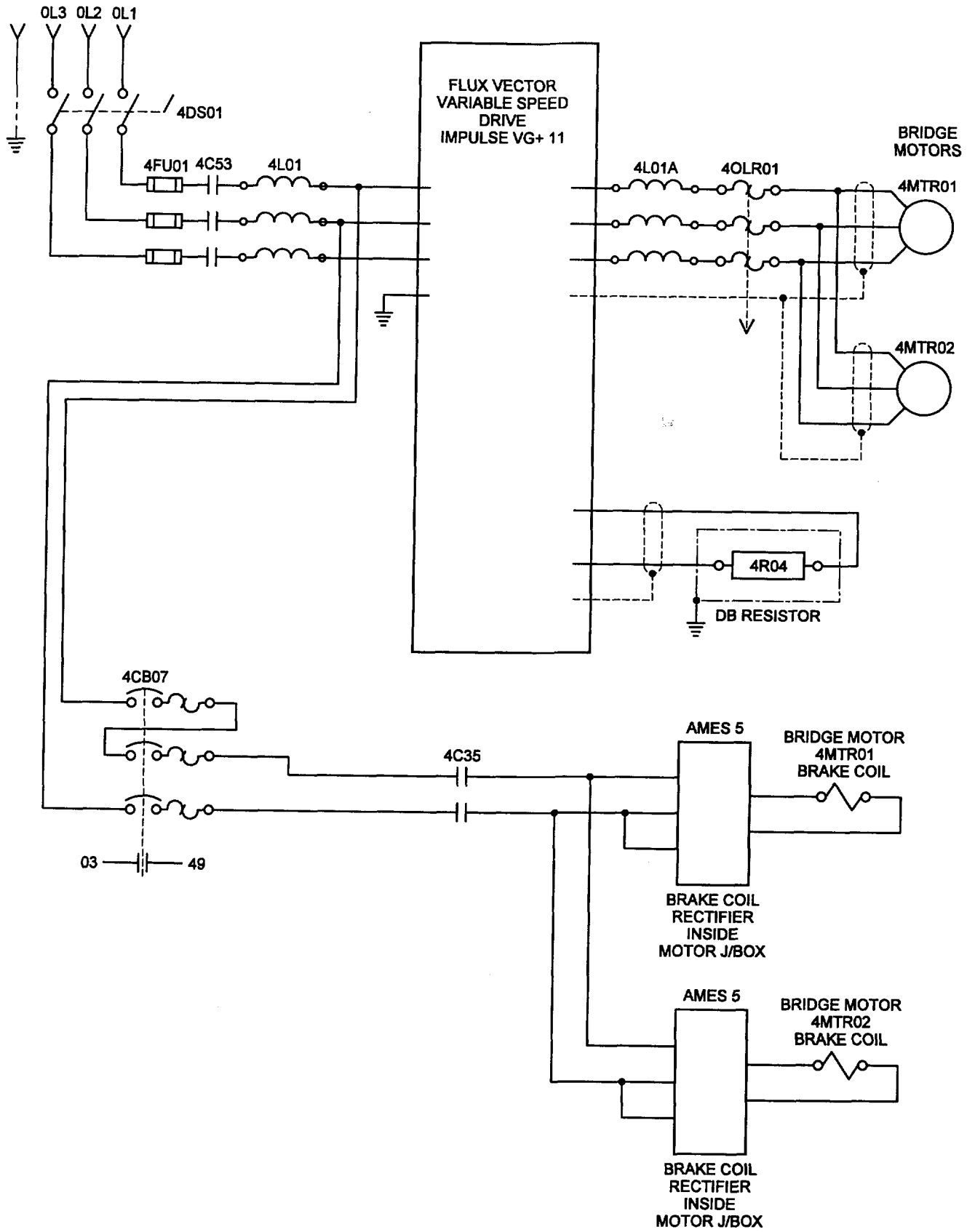


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 9 OF 11)

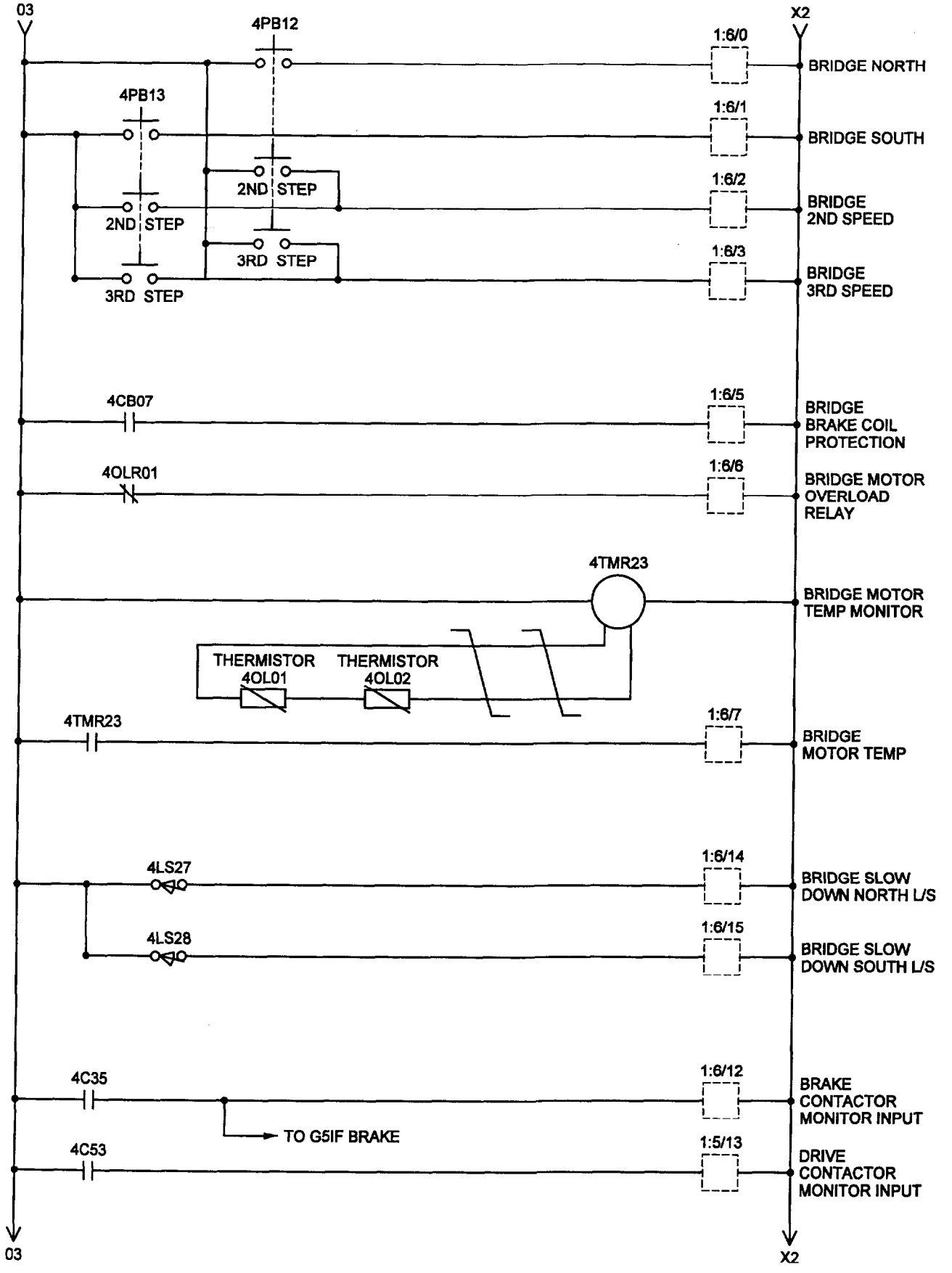


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 10 OF 11)

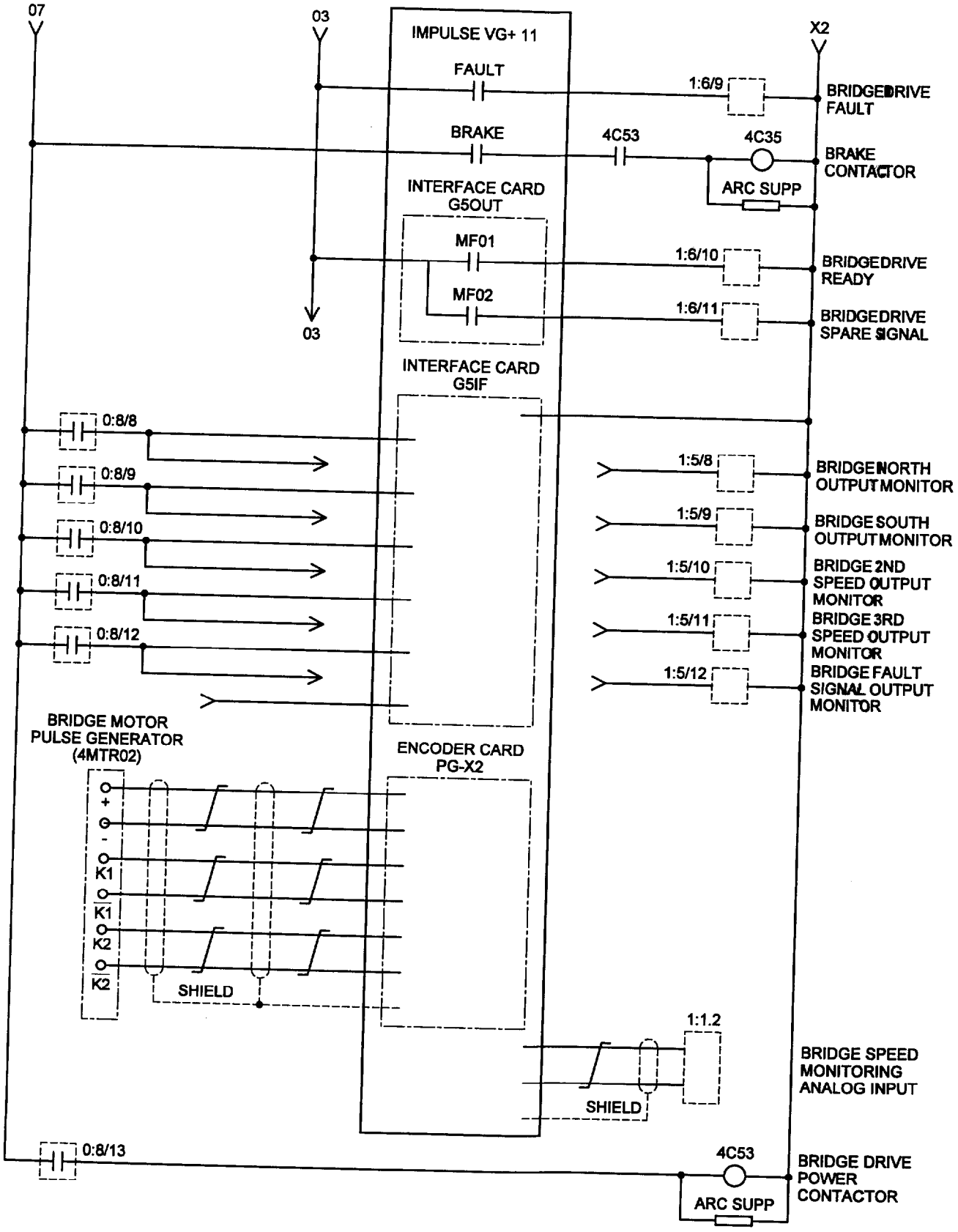


FIGURE 1. CRANE MAIN POWER CONTROL (SHEET 11 OF 11)

Table 6. **Electrical FMEA - Hoist**

System/Subsystem: 10 & 15 Ton Bridge Cranes /Hoist
PMN: H70-1528, H70-1529

Drawing No.: 387-447-49 & 387-446-49
Reference Figure: 1

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
E-Stop (No. 1 - No. 10) 10 Ton Crane (No. 1 - No. 4) 15 Ton Crane A-B Bull. 800T	Emergency Stops	Cut off main power to crane and controls.	Fails open	Cannot power up crane and controls.	No effect.	3
			Fails closed	Backup protection provided by pendent E-Stop. Requires double failure of controls and E-Stop.	No effect.	3
Panel switch A-B Bull. 800T	On-Off- Reset Key Switch mounted on the wall.	Cut off main power to crane and controls.	Fails open	Cannot power up bridge crane and controls.	No effect.	3
			Fails closed	Cannot shut off power to the crane and controls. Delay in operation	No effect..	3
ODS01 ITE-Siemens MCS	Manual disconnect mounted on the wall.	Powers control circuit and crane circuit.	Fails open	Cannot power up crane and controls.	No effect.	3
			Fails closed	Power can be shut off to crane and controls at ODSO3.	No effect.	3
ODS03 ITE-Siemens MCS	Manual disconnect mounted on the bridge	Powers crane rails.	Fails open	Cannot power up crane and controls.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails closed	Power can be shut off to crane and controls at ODSO1.	No effect.	3
C-16	Relay	Powers crane control circuit	Locking contact fails open	Cannot power up crane controls.	No effect.	3
			Locking contact fails closed	Power is maintained in Relay, crane controls will always be powered. Operation will be normal, except when the panel switch is turned to on the controls will be powered without turning the key switch to reset.	No effect.	3
			Control circuit contact fails open.	Crane controls cannot be powered. Cannot operate crane. Delay in operation.	No effect.	3
			Control circuit contact fails closed	Power to crane controls will be powered when crane disconnect is closed. Operation will be normal, except when the crane disconnect is closed the controls will be powered without turning the key switch to reset. Wall E-Stops are ineffective. Requires double failure of controls and pendent E-Stop.	No effect.	3
OCR02	Relay	Provides power to main contactor circuit (OC11)	coil fails open	Cannot power up crane.	No effect.	3
			Contact fails closed	All operations will be normal.	No effect.	3
			Contact fails open	Cannot power up the crane..	No effect.	

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
OC11 Siemens 3TF	Relay	Powers main 480V circuit to crane. Powers 120V circuit to hoist lift & lower pushbuttons. Powers locking contact.	Coil fails open	Cannot power up crane.	No effect.	3
			Locking contact fails closed	Power is maintained in OC11 relay, crane will always be powered. When the panel switch is turned to on the crane will be powered without pushing the pendent button for on. All operations will otherwise be normal.	No effect.	3
			Locking contact fails open	Cannot power up the pendent	No effect	3
			Crane main 480v power circuit contact fails open.	Crane cannot be powered. Cannot operate crane. Delay in operation.	No effect.	3
			120v circuit to pushbuttons contact fails open	Cannot lift or lower a load.	No effect.	3
			120v circuit to pushbuttons contact fails closed	Operation will be normal.	No effect.	3
			Crane main 480v power circuit contact fails closed	When the panel switch is turned to on the crane will be powered without pushing the pendent button for on. All operations will otherwise be normal.	No effect.	3
OPB11A Square D Class 9001	Pendent power button	Completes circuit to OC11 (crane main power relay)	Push button fails open	Cannot power up crane	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Push button fails closed	Pendent power will come on when panel switch KS1is turned to reset. All controls will act normal.	No effect.	3
OPB11 Square D Class 9001	Pendent E-Stop button	Powers off OC11 (crane main power relay)	Push button fails open	Cannot power up crane.	No effect.	3
			Push button fails closed	Will not be able to stop an emergency from the pendent if a control failure were to occur. E-Stops on the wall provide back-up. Double failure of controls and E-Stop required.	No effect.	3
OPMO4 A-B Bull.813S	Phase monitor	Powers off OC11 (crane main power relay) when 480v circuit becomes out of phase.	Switch fails open	Cannot power up crane.	No effect.	3
			Switch fails closed	Operation will be normal until out of phase current causes the crane to act erratic (possible damage to GSE).	No effect.	3
OSL11 Namco EA170	Final upper limit switch (rocker arm) relay.	Powers off OC11 (crane main power relay) when upper limit switch is tripped.	Fails open	Unable to move the load.	No effect.	3
			Fails closed	No effect. Requires double failure of final and initial (S1) upper limit switch for the load to two-block.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
Bypass Square D Class 9001	Final upper limit switch (OSL11) bypass switch	Overrides the final upper limit switch to lower the load when the final upper limit switch is tripped.	Fails open	Unable to lower the load.	No effect.	3
			Fails closed	Load will only be lowered in creep speed.	No effect.	3
1PB12 Square D Class 9001	Lift pushbutton	4 speed pushbutton that raises the load.	Fails open	Unable to lift the load.	No effect.	3
			a. Fails closed b. welded contacts c. NA d. Visual e. Push the E-stop f. 4 sec. g. 3 sec.	Load will continue to be lifted resulting in damage of a vehicle system unless correcting action is taken. Note: If no objects are overhead then double failure of the initial and final limit switch is required for two-blocking.	No effect. Use of correcting action prevents damage of a vehicle system.	3
1PB13 Square D Class 9001	Lower pushbutton	4 speed pushbutton that lowers the load.	Fails open	Unable to lower the load.	No effect.	3
			a. Fails closed b. welded contacts c. NA d. Visual e. Push the E-stop f. 4 sec. g. 3 sec.	Load will continue to be lowered resulting in damage of a vehicle system unless correcting action is taken. Note: Limit switch will not prevent loads from contacting the floor since it is set for the hook. The load will hit the floor possibly causing damage to flight hardware.	No effect. Use of correcting action prevents damage of a vehicle system.	3
DGS-4 (S1, S2) Demag DGS 4	Upper geared limit switches	S1 stops the load when tripped. S2 slows the speed to creep speed when tripped.	S1 fails open	Unable to raise the load.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			S1 fails closed	No effect. Requires double failure of final and initial (S1) upper limit switch for the load to two-block.	No effect.	3
			S2 fails open	Hoist will only raise in creep speed. Delay in operation.	No effect.	3
			S2 fails closed	No effect. S1 will stop the load.	No effect.	3
DGS-4 (S3, S4) Demag DGS 4	Lower geared limit switches	S3 stops the load when tripped. S4 slows the speed to creep speed when tripped. Limit switch is not a safety device for loads, it is used for the hook. Operators are trained not to use the limit switch as a stopping device for the hoist	S3 fails open	Unable to lower the load.	No effect.	3
			S3 fails closed	No effect. Operations remain the same.	No effect. See hazard analysis.	3
			S4 fails open	Hoist can only be lowered in creep speed. Delay in operation.	No effect..	3
			S4 fails closed	No effect. Operations remain the same.	No effect. See hazard analysis.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
1LS30 Klockner-Moeller ATO	Load hold/halt limit switch	Trips motor off when lock pawl contacts the microswitch. The pawl is pushed into the microswitch by the drum ratchet when the pawl is engaged in the drum ratchet due to an overspeed condition.	Fails open	Unable to power the hoist.	No effect.	3
			Fails closed	Lock pawl is mechanically set and will stop the load. The microswitch will not shut the power off to the hoist motor. The PLC may detect an overspeed condition at the vector drive and shut off the power.	No effect.	3
1TRM23 A-B Bull. 817	Relay	Hoist motor temp. monitor. Closes circuit to PLC monitor to shut down motor if overheated.	Fails open (coil, contact)	Unable to power off the motor if overheated. May cause damage to hoist motor.	No effect.	3
			Fails closed (contact)	Unable to power up the hoist.	No effect.	3
1C53 Siemens 3TF	Relay	Hoist drive relay. Closes 480v circuit to variable speed drive. Closes circuit to PLC drive contactor monitor. Closes contact to brake relay 1C35.	Fails open (coil)	Unable to power the variable drive. Hoist will not move up or down. Delay in operation	No effect.	3
			Fails open (480v contacts)	Unable to power the variable drive. Hoist will not move up or down.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails open (PLC drive monitor contact)	Unable to power the monitor. PLC will detect fault. Hoist will not go up or down.	No effect.	3
			Fails open (brake relay contact)	Unable to release the motor brake. Hoist will not go up or down.	No effect.	3
			Fails closed (480v contacts)	The variable drive will be powered. Hoist will operate normally	No effect.	3
			Fail closed (PLC drive monitor contact)	PLC will shut off the hoist when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
			Fails closed (brake relay contact)	1C35 relay will have power. PLC will detect the drive monitor is not powered and shut the hoist operation. Also variable speed drive will detect the fault and shut off the hoist.	No effect.	3
1C35 Siemens 3TF	Relay	Hoist brake relay. Closes circuit to motor brake coil. Closes circuit to PLC brake monitor.	Fails open (coil)	Unable to release the motor brake. Delay in operation	No effect.	3
			Fails open (brake contacts)	Unable to release the motor brake. Motor may drive through the brake, possible to wear brake out prematurely.	No effect.	3
			Fails open (PLC brake monitor contact)	Unable to power the monitor. Hoist will not move up or down.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails closed (brake contacts)	PLC will shut off the hoist when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
			Fails closed (PLC brake monitor contact)	PLC will shut off the hoist when it detects the hoist drive monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
1MTR01 Demag	Hoist motor	Provides torque to rotate the hoist drum.	Inoperative	Cannot operate the hoist.	No effect.	3
1C36	Relay	Hoist brake relay. Closes circuit to motor brake coil. Used to aid in dissipation of energy in coil when opened to set the brake quicker.	Fails open (coil)	Unable to release the motor brake. Delay in operation	No effect.	3
			Fails open (brake contacts)	Unable to release the motor brake. Motor may drive through the brake, possible to wear brake out prematurely.	No effect.	3
			Fails open (PLC brake monitor contact)	Unable to power the monitor. Hoist will not move up or down.	No effect.	3
			Fails closed (brake contacts)	PLC will shut off the hoist when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails closed (PLC brake monitor contact)	PLC will shut off the hoist when it detects the hoist drive monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
XFM05 Hevi-Duty SBE	Transformer	Coverts 480V to 120V to power the wall mounted E-Stops and main power panel.	Fails open	Unable to power up the pendent control circuit.	No effect.	3
			Fails short	Unable to power up the pendent control circuit	No effect	3
1L01, 1L01A Electromotive 5% Imp.	Line Reactors	Conditions the 480V input power to the drive circuit.	Fails short	Unable to operate the hoist.	No effect.	3
			Fails open to ground	Unable to operate the hoist.	No effect.	3
1CB07 Siemens 3VU	Circuit breaker	Protects the 480V circuit to the hoist motor brake from high voltages and current. Opens circuit to PLC hoist brake coil protection.	Premature trip	Unable to release the hoist motor brake. PLC and variable drive will detect the fault and shut down the crane	No effect	3
			Circuit breaker fails to trip	Current overload of circuit. Possible damage to GSE.	No effect	3
			PLC contact fails open	PLC will not let the hoist be powered up.	No effect	3
			PLC contact fails closed	PLC will not detect that the CB has tripped to shut off the hoist. Brakes will set and hoist will not move. Loss of PLC monitor only.	No effect	3
1OLR01 Siemens 3UA	Overload relay	Protects the hoist motor from high current.	Premature trip	Unable to run the hoist motor.	No effect	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails to trip	Overload of current to the motor may result. Possible damage to GSE (brake coil).	No effect	3
			Contact fails open	PLC will show fault, hoist will not operate .	No effect	3
			Contact fails closed	PLC will not detect a fault, damage to GSE (motor) may occur.	No effect	3
Impulse VG+ Series 2 Electromotive	Flux vector drive	Controls motor speed and torque.	Unsolicited command	No effect. The PLC would shut the crane off.	No effect.	3

Table 7. **Electrical FMEA - Trolley**

System/Subsystem: 10 & 15 Ton Bridge Cranes / Trolley
PMN: H70-1528, H70-1529

Drawing No.:387-447-49 & 387-446-49
Reference Figure: 2

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
3FUO1 Gould/ Shwmut AJT	Fuse	Protects the 120v drive circuit from high current.	Premature operation	Unable to operate the trolley.	No effect.	3
			Fails to operate	Current overload could damage the drive and stop trolley operations. Possible damage to GSE.	No effect.	3
3L01 3L01A Electromotive 5% Imp.	Line Reactor	Conditions the 480V input power to the drive circuit.	Fails short	Unable to operate the trolley.	No effect.	3
			Fails open to ground	Unable to operate the trolley.	No effect.	3
3CB07 Siemens 3VU	Circuit Breakers	Protects the trolley motor brake coil from high current.	Premature trip	Unable to release the trolley motor brake.	No effect	3
			Fails to trip	Overload of current to the brake coil may result. Possible damage to GSE (brake coil).	No effect	3
			PLC contact fails open	PLC will not let the trolley be powered up.	No effect	3
			PLC contact fails closed	PLC will not detect that the CB has tripped to shut off the trolley. Brakes will set and trolley will not move. Loss of PLC monitor only.	No effect	3
3OLR01 Siemens 3UA	Overload relay	Protects the trolley motor from high current.	Premature trip	Unable to run the trolley motor.	No effect	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails to trip	Overload of current to the motor may result. Possible damage to GSE (brake coil).	No effect	3
			Contact fails open	PLC will show fault, trolley will not operate.	No effect	3
			Contact fails closed	PLC will not detect a fault, damage to GSE (motor) may occur.	No effect	3
3MTR01 Demag	Motor	Provides torque to rotate the trolley wheels.	Inoperative	Cannot operate the trolley.	No effect.	3
3TMR23 A-B Bull. 817	Relay	Trolley motor temp. monitor. Closes circuit to PLC monitor to shut down motor if overheated.	Fails open (coil, contact)	Unable to power off the motor if overheated. May cause damage to GSE	No effect.	3
			Fails closed (contact)	Unable to power up the trolley.	No effect.	3
3PB12 Square D Class 9001	Trolley east pushbutton	2 speed pushbutton that moves the trolley east	Fails open	Unable to move the trolley.	No effect.	3
			a. Fails closed b. welded contacts c. NA d. Visual e. Push the E-stop f. 4 sec. g. 3 sec.	Load will continue to move east resulting in damage of a vehicle system unless correcting action is taken. Note: Limit switch is useless with loads being moved since it is set for the hook.	No effect. Use of correcting action prevents damage of a vehicle system.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
3PB13 Square D Class 9001	Trolley west pushbutton	2 speed pushbutton that moves the trolley west.	Fails open	Unable to move the trolley.	No effect.	3
			a. Fails closed b. welded contacts c. NA d. Visual e. Push the E-stop f. 4 sec. g. 3 sec.	Load will continue to move west resulting in damage of a vehicle system unless correcting action is taken. Note: Limit switch is useless with loads being moved since it is set for the hook.	No effect. Use of correcting action prevents damage of a vehicle system.	3
3LS27	East limit switch	Stops the trolley when tripped. Limit switch is not a safety device for loads, it is used for the hook. Operators are trained not to use the limit switch as a stopping device for the trolley	Fails open	Unable to move the trolley.	No effect.	3
			Fails closed	No effect. Operations remain the same.	No effect. See hazard analysis.	3
3LS28	West limit switch	Stops the trolley when tripped. Limit switch is not a safety device for loads, it is used for the hook. Operators are trained not to use the limit switch as a stopping device for the trolley	Fails open	Unable to move the trolley.	No effect.	3
			Fails closed	No effect. Operations remain the same.	No effect. See hazard analysis.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
3C53 Siemens 3TF	Relay	Trolley drive relay. Closes 480v circuit to variable speed drive. Closes circuit to PLC drive contactor monitor. Closes contact to brake relay 3C35.	Fails open (coil)	Unable to power the variable drive. Trolley will not move. Delay in operation.	No effect.	3
			Fails open (480v contacts)	Unable to power the variable drive. Trolley will not move. Delay in operation.	No effect.	3
			Fails open (PLC drive monitor contact)	Unable to power the monitor. PLC will detect fault. Trolley will not move. Delay in operation.	No effect.	3
			Fails open (brake relay contact)	Unable to release the motor brake. Trolley will move. Delay in operation.	No effect.	3
			Fails closed (480v contacts)	The variable drive will be powered. Trolley will operate normally	No effect.	3
			Fail closed (PLC drive monitor contact)	PLC will shut off the trolley when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
			Fails closed (brake relay contact)	3C35 relay will have power. PLC will detect the drive monitor is not powered and shut the trolley operation. Also variable speed drive will detect the fault and shut off the hoist. Delay in operation.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
3C35 Siemens 3TF	Relay	Trolley brake relay. Closes circuit to motor brake coil. Closes circuit to PLC brake contactor monitor.	Fails open (coil)	Unable to release the motor brake. Delay in operation	No effect.	3
			Fails open (brake contact)	Unable to release the motor brake. Trolley will not move east or west.	No effect.	3
			Fails open (PLC brake monitor contact)	Unable to power the monitor. Trolley will not move east or west.	No effect.	3
			Fails closed (brake contacts)	PLC will shut off the trolley when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
			Fails closed (PLC drive monitor contact)	PLC will shut off the trolley when monitor detects the brake relay is not powered. Delay in operation.	No effect.	3
Impulse VG+ Series 2 Electromotive	Flux vector drive	Controls motor speed and torque.	Unsolicited command	No effect. The PLC would shut the crane off.	No effect.	3

Table 8. **Electrical FMEA - Bridge**

System/Subsystem: 10 & 15 Ton Bridge Cranes / Bridge
PMN: H70-1528, H70-1529

Drawing No.:387-447-49 & 387-446-49
Reference Figure 2

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
4FUO1 Gould/ Shawmut AJT	Fuse	Protects the 120v drive circuit from high current.	Premature operation	Unable to operate the bridge.	No effect.	3
			Fails to operate	Current overload could damage the drive and stop bridge operations. Possible damage to GSE.	No effect.	3
4L01 4L01A Electromotive 5% Imp.	Line Reactors	Conditions the 480V input power to the drive circuit.	Fails short	Unable to operate the bridge.	No effect.	3
			Fails open to ground	Unable to operate the bridge.	No effect.	3
4CB07 Siemens 3VU	Circuit Breakers	Protects the trolley motor brake coil from high current.	Premature trip	Unable to release the bridge motor brake.	No effect	3
			Fails to trip	Overload of current to the brake coil may result. Possible damage to GSE (brake coil).	No effect	3
			PLC contact fails open	PLC will not let the bridge be powered up.	No effect	3
			PLC contact fails closed	PLC will not detect that the CB has tripped to shut off the bridge. Brakes will set and bridge will not move. Loss of PLC monitor only.	No effect	3
4OLR01 Siemens 3UA	Overload relay	Protects the bridge motor from high current.	Premature trip	Unable to run the bridge motor.	No effect	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			Fails to trip	Overload of current to the motor may result. Possible damage to GSE (brake coil).	No effect	3
			Contact fails open	PLC will show fault, bridge will not operate.	No effect	3
			Contact fails closed	PLC will not detect a fault, damage to GSE (motor) may occur.	No effect	3
4MTR01 Demag	Motors (2)	Provides torque to rotate the bridge wheels	Inoperative	Cannot operate the bridge.	No effect.	3
4TMR23 A-B Bull. 817	Relay	Bridge motor temp. monitor. Closes circuit to PLC monitor to shut down motor if overheated.	Fails open (coil, contact)	Unable to power off the motor if overheated. May cause damage to GSE	No effect.	3
			Fails closed (contact)	Unable to power up the bridge.	No effect.	3
4PB12 Square D Class 9001	Bridge north pushbutton	3 speed pushbutton that moves the bridge north.	Fails open	Unable to move the bridge.	No effect.	3
			a Fails closed b Welded contacts c NA d Visual e Push the E-stop f 3 sec. g 4 sec.	Bridge will continue to move north resulting in damage of a vehicle system unless correcting action is taken. Note: Limit switch will not prevent loads from contacting the obstructions since it is set for the hook	No effect. Use of correcting action prevents damage of a vehicle system.	3
4PB13 Square D Class 9001	Bridge south pushbutton	3 speed pushbutton that moves the bridge south.	Fails open	Unable to move the bridge.	No effect.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
			a Fails closed b Cause c NA d Visual e Push the E-stop f 3 sec. g 4 sec.	Bridge will continue to move south resulting in damage of a vehicle system unless correcting action is taken. Note: Limit switch is useless with loads being moved since it is set for the hook	No effect. Use of correcting action prevents damage of a vehicle system.	3
4LS27	North limit switch	Slows down the bridge (10 ton crane) when tripped. Stops the bridge (15 ton crane) when tripped. Limit switch is set for hook not various loads being moved.	Fails open	Bridge (10 ton) will only move in creep speed. Cannot move the bridge (15 ton).	No effect.	3
			Fails closed	Limit switch is not a safety device for loads, it is used for the hook. Operators are trained not to use the limit switch as a stopping device for the bridge..	No effect. See hazard analysis.	3
4LS28	South limit switch	Slows down the bridge (10 ton crane) when tripped. Stops the bridge (15 ton crane) when tripped. Limit switch is set for hook not various loads being moved.	Fails open	Bridge (10 ton) will only move in creep speed. Cannot move the bridge (15 ton). .	No effect.	3
			Fails closed	Limit switch is not a safety device for loads, it is used for the hook. Operators are trained not to use the limit switch as a stopping device for the bridge.	No effect. See hazard analysis.	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
4C53 Siemens 3TF	Relay	Bridge drive relay. Closes 480v circuit to variable speed drive. Closes circuit to PLC drive contactor monitor. Closes contact to brake relay 3C35.	Fails open (coil)	Unable to power the variable drive. Bridge will not move. Delay in operation.	No effect.	3
			Fails open (480v contacts)	Unable to power the variable drive. Bridge will not move. Delay in operation.	No effect.	3
			Fails open (PLC drive monitor contact)	Unable to power the monitor. PLC will detect fault. Bridge will not move. Delay in operation.	No effect.	3
			Fails open (brake relay contact)	Unable to release the motor brakes. Bridge will move. Delay in operation.	No effect.	3
			Fails closed (480v contacts)	The variable drive will be powered. Bridge will operate normally	No effect.	3
			Fail closed (PLC drive monitor contact)	PLC will shut off the bridge when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
			Fails closed (brake relay contact)	4C35 relay will have power. PLC will detect the fault through the drive monitor and shut the bridge operation. Also variable speed drive will detect the fault and shut off the hoist. Delay in operation.	No effect	3

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
4C35 Siemens 3TF	Relay	Bridge brake relay. Closes circuit to motor brake coil. Closes circuit to PLC brake contactor monitor.	Fails open (coil)	Unable to release the motor brake. Delay in operation	No effect.	3
			Fails open (brake contact)	Unable to release the motor brake. Bridge will not move north or south.	No effect.	3
			Fails open (PLC brake monitor contact)	Unable to power the monitor. Bridge will not move north or south.	No effect.	3
			Fails closed (brake contacts)	PLC will shut off the bridge when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
			Fails closed (PLC drive monitor contact)	PLC will shut off the bridge when it detects the hoist brake monitor or drive pushbutton is not powered. Delay in operation.	No effect.	3
Impulse VG+ Series 2 Electromotive	Flux vector drive	Controls motor speed and torque.	Unsolicited command	No effect. The PLC would shut the crane off.	No effect.	3

Table 9. **Electrical FMEA - PLC**

System/Subsystem: 10 & 15 Ton Bridge Cranes / PLC
PMN: H70-1528, H70-1529

Drawing No.: 387-447-49 & 387-446-49
Reference Figure: None

Find No. Part No.	Part Name	Part Function	a. Failure Mode b. Cause c. FMN d. Detection Method e. Correcting Action f. Time to Effect g. Timeframe	Failure Effect On System Performance	Failure Effect On Vehicle Systems And/Or Personnel Safety	Crit Cat
PLC SLC 5/03	Programmable logic controller	Performs control for the motion of the hoist, trolley and bridge.	a. Unsolicited command. b. Internal component failure or software failure. c. 09CR00-001.003 d. Visual e. Operator or observer pushes E-Stop. f. 1 second g. 3 seconds	PLC could initiate or continue a crane motion in an uncommanded direction or speed resulting in loss of life and/or damage to a vehicle system.	Loss of Life and/or loss/damage to a vehicle system.	1

4.3 LPS CONTROL / MONITOR REVIEW

There is no LPS control / monitor interface associated with this system.

5 HAZARDS ANALYSIS

The Fault Tree Analysis and Hazard Analysis worksheets follow.

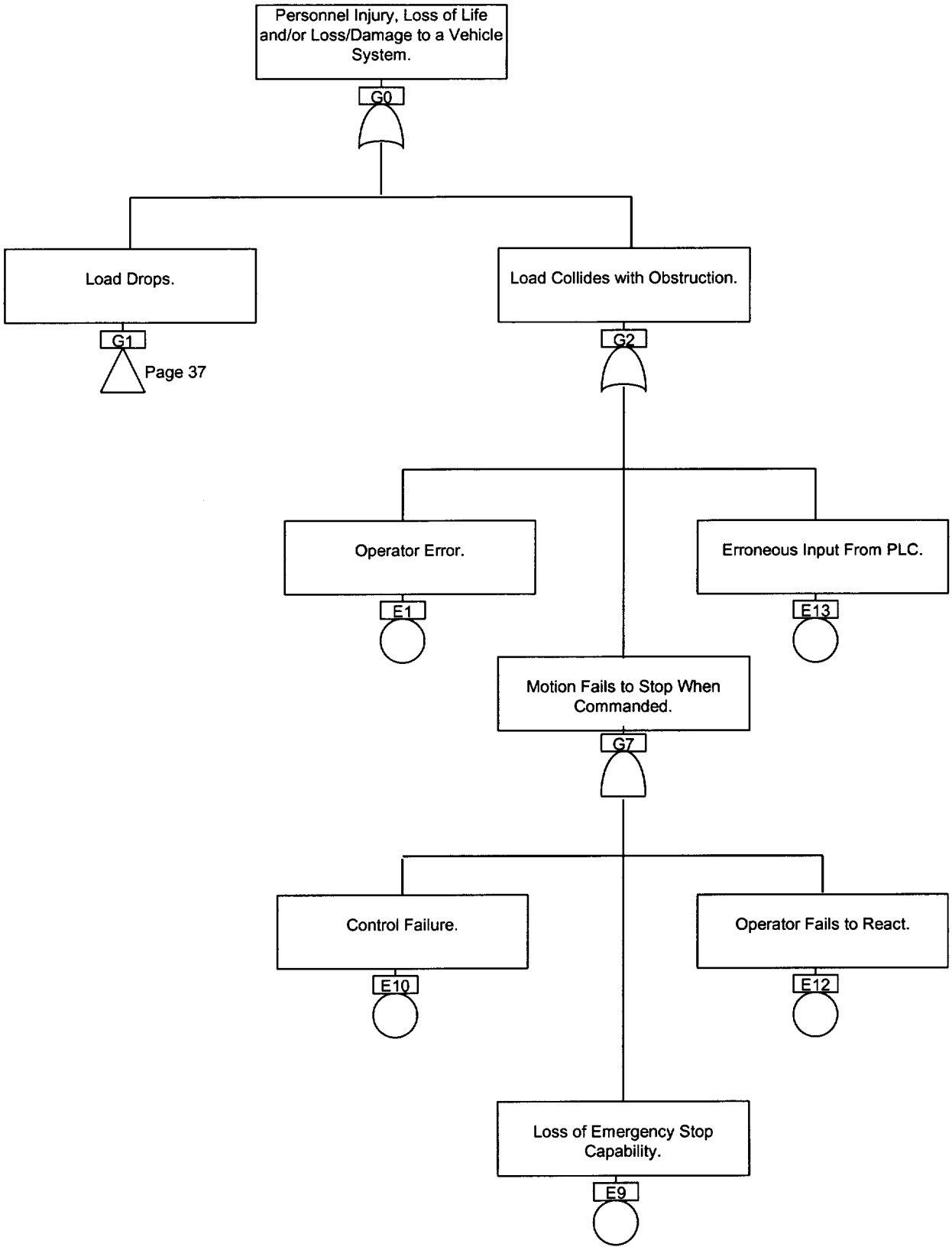


Figure 2. 10 & 15 Ton Bridge Cranes Fault Tree

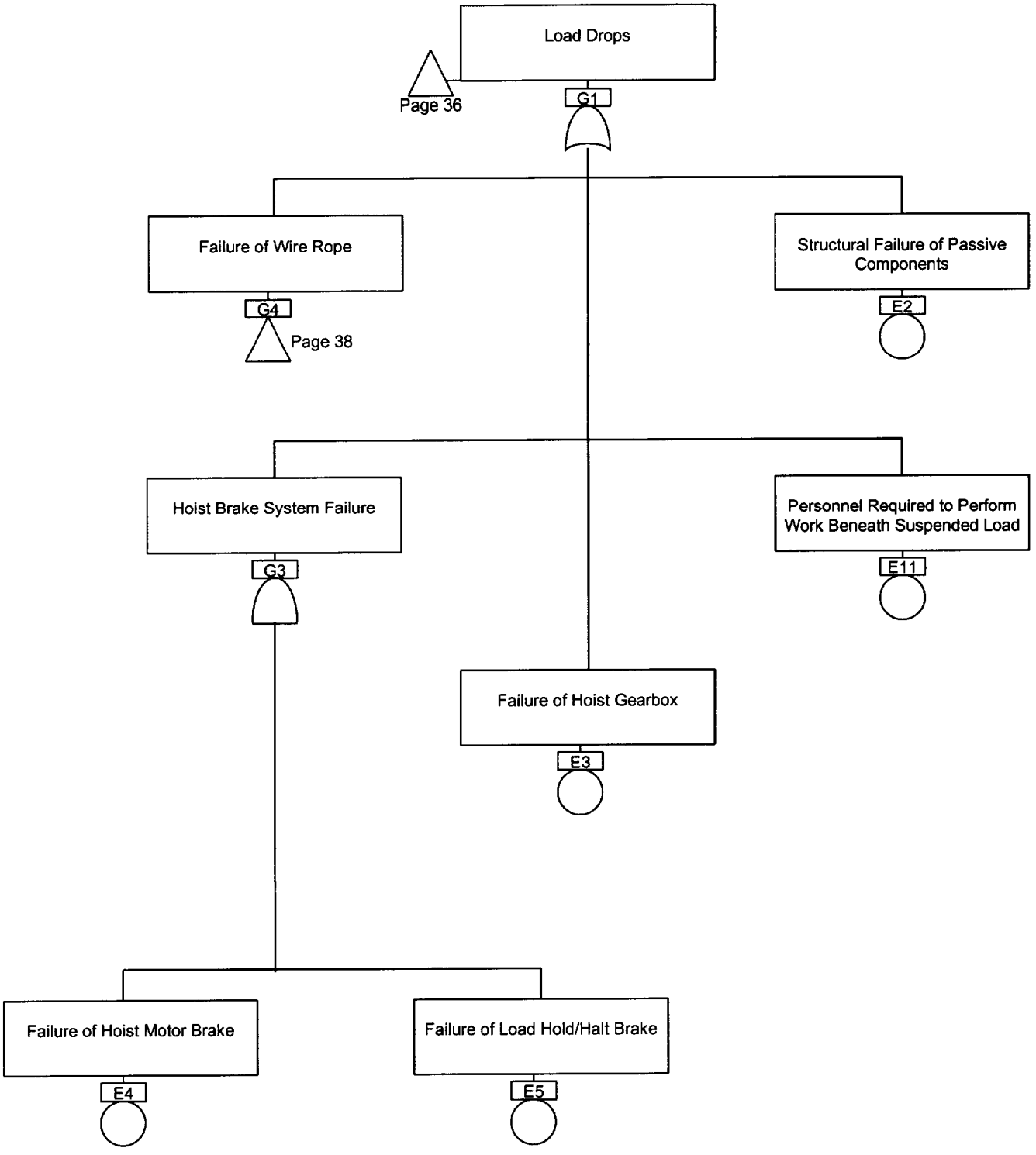


Figure 2. 10 & 15 Ton Bridge Cranes Fault Tree (continued)

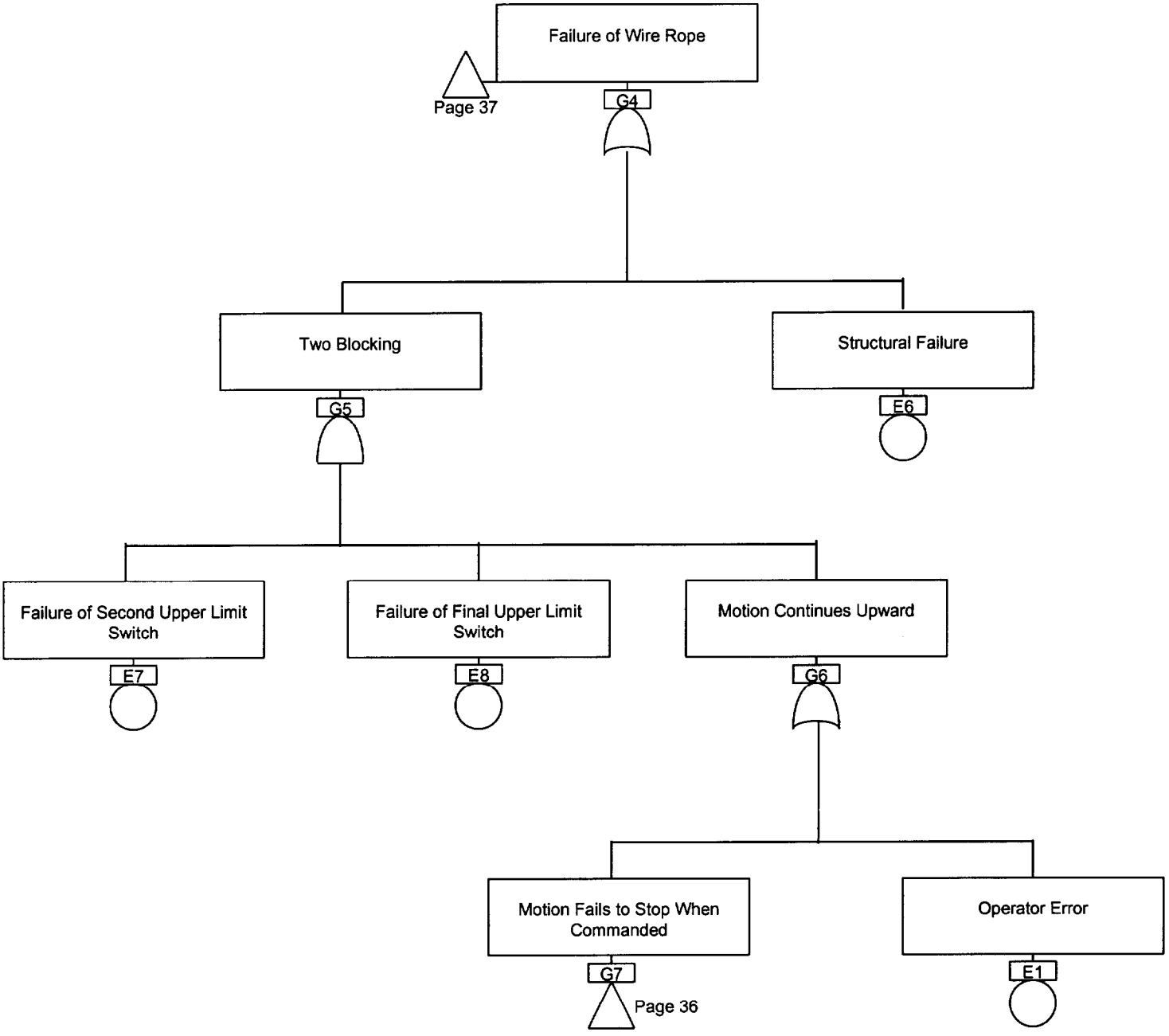


Figure 2. 10 & 15 Ton Bridge Cranes Fault Tree (continued)

Table 10. **Hazard Analysis Worksheet**

System/Subsystem: 10 & 15 Ton Bridge Cranes
PMN: H70-1528, H70-1529
Location: SSMEPF

Event No.	Event Nomenclature (Hazard Cause)	Hazard Elimination / Control Verification
E1	Operator error	Critical skills (CSR 093) verified prior to lifting operations.
E2	Structural failure of passive components	Periodic inspection and maintenance includes monthly inspection of structural members, bridge and trolley assemblies, hoist drum and general inspection for corrosion, annual hook magnaflux, and annual load test per OMI Q6343.
E3	Failure of hoist gearbox	Hoist gearbox designed to AGMA standards per manufacturers specifications. Periodic maintenance performed including annual load test per OMI Q6343. Load hold/halt drum brakes prevent dropping of the load in event of gearbox failure.
E4	Failure of hoist motor brake	Double failure required. Periodic inspection and maintenance includes monthly visual inspection of load hold mechanism and motor brake, and annual load hold brake and motor brake test under 100% rated load per OMI Q6343.
E5	Failure of load hold/halt brake	Same as E4
E6	Structural failure	The rated capacity load divided by the number of parts of rope does not exceed 20% of the breaking strength of the rope per manufacturer's specifications. Periodic maintenance and inspection includes monthly inspection of wire rope and wire rope terminations and annual load test per OMI Q6343.
E7	Failure of initial upper limit switch	Double failure required. Hoist provided with final upper limit switch after initial upper limit switch. Periodic maintenance includes monthly inspection of initial and final upper limit switch and monthly operational check of all limit switches per OMI Q6343.
E8	Failure of final upper limit switch	Same as E7
E9	Loss of emergency stop capability	Periodic maintenance includes monthly inspection and operational test of pendent and remote E-Stops per OMI Q6343.
E10	Control failure	Periodic maintenance includes monthly inspection and operational test of control station per OMI Q6343. 79K16497 (General OMRSD for Load Sensitive Cranes/Hoists) states that any time a critical load is within three feet of any structure operate crane at low speed.

Event No.	Event Nomenclature (Hazard Cause)	Hazard Elimination / Control Verification
E11	Personnel required to perform work beneath suspended load	Only operations approved by suspended load operation analysis/approval prepared per NASA standard for suspended load operations provided in NSS/GO 1740.9 allow personnel under a suspended load (ref. SLOAA 1991-016, 017, 018 and 019) Only approved number of personnel allowed under a suspended load for time required to accomplish task. Only trained and certified personnel may operate cranes. Critical skills (CSR 093) verified prior to lifting operations. Periodic maintenance and inspection performed including monthly operational checks per OMI Q6343.
E12	Operator fails to react	Critical skills verified for crane operators and observers prior to critical lifts given per OMI V6G21,V5E28, V5E02, V5E63 and V5087. Emergency instructions for critical lifts given per OMI V6G21,V5E28, V5E02, V5E63 and V5087.
E13	Erroneous input from PLC	Periodic maintenance includes monthly inspection per OMI Q6343 and operational test of PLC prior to critical lifts per operating instructions (OI) 105. Power is removed at the pendent control whenever the pendent is unmanned or whenever the load is static as written in all OMIs..

Appendix A
CRITICAL ITEMS LIST SHEETS

Critical Item: Programmable Logic Controller (PLC)
NASA Part No: None
Mfg/Part No: Allen-Bradley / SLC 5/03
System 10 & 15 Ton Bridge Cranes

Criticality Category: 1
Total Quantity: 2

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
PLC	1	SSMEPF	H70-1528	036.00	Demag 387 447 49 / 3
PLC	1	SSMEPF	H70-1529	036.00	Demag 387 446 49 / 3

Function:

Performs control for the motion of the hoist, trolley and bridge.

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09CR00-001.003 Unsolicited command	Internal component failure or software failure. PLC could initiate or continue a crane motion in an uncommanded direction or speed resulting in loss of life and/or loss/damage to a vehicle system	Visual 1 second	1

ACCEPTANCE RATIONALE

Design:

- Designed to industry standards. UL listed.
- Internal diagnostics verify all crane controls each time the crane is used.
- The PLC is electrically isolated from external voltages/currents.
- An overspeed activated load hold/halt drum brake prevents free fall of the load.
- The E-Stop circuits are independent from the PLC circuit.
- The software was written and incorporated by the contractor.

Test:

- Crane software was validated and tested per the acceptance test procedure.
- Before each use functional checks of the hoist, trolley and bridge will be performed in all axis per OI O-105.
- Proofload test has been performed in accordance with NSS/GO-1740.9. During this test validation of the functional operations of the crane was accomplished.
- OMRS File VI requires the performance of an annual operational test to verify proper operation of all crane controls. The test will show that all limit switches, E-Stops, and speeds indicate the PLC performs as expected.

Inspection:

- None

Failure History:

- No failures were experienced during validation testing.
- Current data on test failures, unexplained anomalies, and other failures experienced during ground processing activities can be found in the PRACA database. The PRACA database was researched and no data was found on this type of component in the critical failure mode.

Operational Use:

Correcting Action	Timeframe
• Operator or observers may mitigate the failure effect by pushing the E-stop. • At any time the pendent is left unmanned or the load is in a static position power to the crane will be removed through the pendent E-Stop. • A wall mounted E-Stop will be manned during all critical lifts and suspended load operations.	3 seconds

1R Non-CIL Item: Hoist load Hold/Halt Drum Brake
Criticality Category: 1R
NASA Part No: None
Total Quantity: 2
Mfg/Part No: Demag / 407 638 44
System 10 & 15 Ton Bridge Cranes

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
None	1	SSMEPF	H70-1528	036.00	Demag 387 447 49 / 3
None	1	SSMEPF	H70-1529	036.00	Demag 387 446 49 / 3

Function:

Provides retarding torque to hold load when no power is being transmitted if the load moves down after stopping. Electrically released brake assembly applies load holding torque directly to hoist drum.

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09CR00-001.001 Fails to engage	Damaged or broken gear teeth/pawl mechanism, solenoid or improper adjustment. Loss of torque to hold the load.	Visual Immediate	1R

ACCEPTANCE RATIONALE

Redundancy Screens:

		Pass/Fail
A	Item is verifiable during normal ground operations	Pass
B	Item loss is readily detectable by the ground crew	N/A
C	Loss of all redundant items cannot result from a single cause	Pass

Conforms to NSTS 08080-1: N/A

Test and Inspection:

OMRS File VI requires an annual operational independent brake test.

1R Non-CIL Item: Hoist motor brake
NASA Part No: None
Mfg/Part No: Demag / KLA 160 A4
System 10 & 15 Ton Bridge Cranes

Criticality Category: 1R
Total Quantity: 2

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
None	1	SSMEPF	H70-1528	036.00	Demag 387 447 49 / 3
None	1	SSMEPF	H70-1529	036.00	Demag 387 446 49 / 3

Function:

Provides retarding torque to hold load when no power is being transmitted. Electrically released disc brake assembly normally set by spring compression to apply load holding torque to the motor shaft..

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09CR00-001.002 Fails to engage	Brake pad wear/improper adjustment. Loss of torque to hold the load. Subsequent failure of the Hold/Halt drum brake would cause the load to drop. Possible loss of life or vehicle.	Visual Seconds	1R

ACCEPTANCE RATIONALE

Redundancy Screens:

		Pass/Fail
A	Item is verifiable during normal ground operations	Pass
B	Item loss is readily detectable by the ground crew	Pass
C	Loss of all redundant items cannot result from a single cause	Pass

Conforms to NSTS 08080-1: N/A

Test and Inspection:

OMRS File VI requires an annual operational independent brake test.

1R Non-CIL Item: Hoist gearbox
NASA Part No: None
Mfg/Part No: Demag / AFM 06
System 10 & 15 Ton Bridge Cranes

Criticality Category: 1R
Total Quantity: 2

Find No.	Qty	Area	PMN	Baseline	Drawing / Sheet
None	1	SSMEPF	H70-1528	036.00	Demag 387 447 49 / 3
None	1	SSMEPF	H70-1529	036.00	Demag 387 446 49 / 3

Function:

Transmits power from the hoist motor to the hoist drum.

Failure Mode No. Failure Mode	Failure Cause Failure Effect	Detection Method Time to Effect	Crit Cat
09CR00-001.004 Gear disengagement	Worn or broken gear teeth. Loss of ability to hold the load. Subsequent failure of the Hold/Halt drum brake would cause the load to drop. Possible loss of life.	Visual Seconds	1R

ACCEPTANCE RATIONALE

Redundancy Screens:

		Pass/Fail
A	Item is verifiable during normal ground operations	Pass
B	Item loss is readily detectable by the ground crew	Pass
C	Loss of all redundant items cannot result from a single cause	Pass

Conforms to NSTS 08080-1: N/A

Test and Inspection:

OMRS File VI requires the performance of an annual operational test

Appendix B
HAZARD REPORTS

Hazard # : LL-0012 Revision : C Revision Date : 06/29/98
Master # : K-SPC-00000-I-CR Date Identified : 04/06/95 Team / Log : LL / 12

Title : **PERSONNEL REQUIRED TO PERFORM WORK WHILE BENEATH SUSPENDED LOADS DURING FLIGHT HARDWARE PROCESSING AT KSC/DFRF/CLS/VAFB**

CONFIGURATION DATA

Responsible Organization : **SFOC**
CR : **SSP-68095R1**

Mission Effectivity : **26+**
Mission Phase : **GROUND PROCESSING**

Location/Station Sets : **17, 19, 20, 22, 23, 24, 29, 31, 32, 33, 77, 89, BD**

Baselines : **036.00, 237.00, 242.00, 259.00, 330.00, 380.00, 389.00, 400.15, 422.00, 423.00, 505.21, 510.00**

Program Model Numbers : **C70-0870, H70-0822, H70-1379, H70-1379-01, H70-1502, H70-1503, H70-1528, H70-1529, H70-8392, H72-1200, H72-1390, H72-1394, K60-0382, K60-0528, K60-0531, K60-0533, K60-0534, K60-0562, K60-0563, K60-0602, K61-0168, K61-0254, K61-2062**

Flow Segments : **LRR, MULTI, OPF, PAD, PLOAD, RDF, RPSF, SSMEPF, VABM, VABO, VABS, VABT**

HAZARDS ANALYSIS DATA

Report Status : **CLOSED**
Closure Class : **CONTROLLED**

Worst Case Cause : **1**
Severity : **CATASTROPHIC**
Likelihood : **IMPROBABLE**

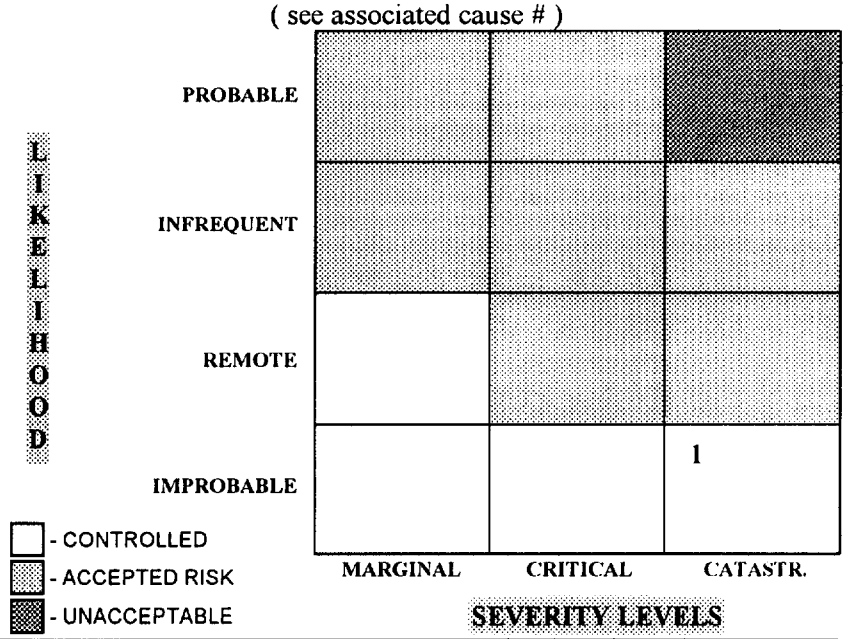
Hazard Type : **INDUSTRIAL**

Prepared By : **USA**
Mail Code : **USK-291**

Analysis Type : **OPERATING & SUPPORT**

RISK MATRIX

Hazard severity and likelihood of occurrence with controls in place
(see associated cause #)



APPROVALS :	DATE :	DATE APPROVED :
Safety Engineer : **Mark Gross**	**09/16/98**	CCB : **10/13/98**
Contractor System / Design Engineer : **Ed Thompson**	**09/18/98**	SSRP :
Contractor Safety Manager (1) : **D. R. Clarkson**	**09/18/98**	PRCB :
Contractor Safety Manager (2) : **A. M. Stevens**	**09/28/98**	
NASA System Engineer : **N/A**		
NASA Safety Manager (1) : **N/A**		
NASA Safety Manager (2) : **N/A**		

Hazard # : LL-0012 | Revision : C | Revision Date : 06/29/98
Master # : K-SPC-00000-I-CR | Date Identified : 04/06/95 | Team / Log : LL / 12

HAZARD DESCRIPTION :

Current procedures for flight hardware processing at KSC, DFRF, CLS and VAFB require personnel to perform work while beneath suspended loads during certain lifting operations. The following lifting devices are used to perform operations which require personnel to perform work while beneath suspended loads:

1) VAB 250-Ton Bridge Crane-External Tank (ET) processing and storage per OMIs T5002.012, T5002.015 and S0033; Inspection and preparation of SRM/SRB components for mate per OMI B5303; Preparations for Orbiter mate to ET per OMI S0004; Orbiter demate from ET per OMI S0030, SRB destacking per OMI B5141; and P/L canister rotation per OMI E5010.

2) VAB 325-Ton Overhead Bridge Crane-External tank processing and storage per OMIs, T5002.012, T5002.015 and, S0033; inspection and preparation of SRM/SRB components for mate per OMI B5303; preparations for Orbiter mate to ET per OMI S0004; Orbiter demate from ET per OMI S0030; SRB destacking per OMI B5141; and payload canister rotation per OMI E5010.

3) VAB 175-Ton Bridge Crane-External tank processing and storage per OMIs T5002.012, T5002.015, and S0033; Preparations for Orbiter mate to ET per OMI S0004; Orbiter demate from ET per OMI S0030; and P/L canister rotation per OMI E5010.

4) RPSF 200-Ton Bridge Crane-SRB processing including Aft Booster assembly and preparations for transport to VAB per OMI B5309; and AFT Booster disassembly per OMI B5143.

5) MDD 55-Ton Hoists (KSC/DFRF) - Post-landing deservicing, Orbiter / SCA mate/demate, and Orbiter towing operations per OMIs S5001, S5022, S5041 and V5112.

6) OPF 30-Ton Bridge Cranes (HBs 1, 2 and 3) - Installation / Removal of horizontal payload into/from P/L canister per OMI E5006. Installation/Removal of Payload Bay Door Lightweight Strongbacks per OMI V9023.001.

7) Pad A/B Clean Access Platform (CAP) Hoists-Orbiter payload bay operations per OMI V5136.

8) 250-Ton Linkbelt HC-268 Mobile Truck Crane-Orbiter/SCA mate at Contingency Landing Sites per OMI S5044; and Payload handling at a CLS per OMI E5532.

9) 800-Ton Demag TC 4000 Mobile Truck Crane-Orbiter/SCA mate at Contingency Landing Sites per OMI S5044; and Payload handling at a CLS per OMI E5532.

10) VAB 10-Ton Bridge Cranes in Checkout Cells 1and 2 to support contingency SSME operation, Preventive Maintenance/SSME Rotating Sling Maintenance per OMI V6G21 and Space Shuttle Main Engine (SSME) Rotation, SSME Move Vertical to Vertical, and Rotating Sling Functional Checkout per OMI V5087.

11) 90-Ton Hoist (Pad A) - Payload canister handling at the Pad per OMI E5026.

12) 90-Ton Hoist (Pad B) - Payload canister handling at the Pad per OMI E5026.

13) OPF Orbiter Zero Gravity (G) Simulator Hoists - Contingency operations to inspect, adjust, and repair the Orbiter payload bay doors per OMI V9023.

14) OLF 50 Ton Hoists (Palmdale) - Orbiter/SCA Mate/Demate per OMIs S5045 & S5046.

15) 40-Ton Link Belt HSP-8040 Mobile Crane - SSME Rotating Sling preventive maintenance and SSME maintenance per OMI V6G21.

16) 35-Ton Pettibone Mobile Crane - SSME Rotating Sling preventive maintenance and SSME maintenance per OMI V6G21.

17) 140-Ton Manitowoc Mobile Crane - SSME Rotating Sling preventive maintenance and SSME maintenance per OMI V6G21. SSME/GSE handling operations per OMI V5082.

18) SSMEPF 10-Ton Bridge Cranes in SSME Work Stand Area-SSME rotating, 1G Simulator functional checkout / test, engine loading / unloading, low pressure oxidizer duct installation / removal, and SSME main combustion chamber removal/installation per OMIs V5087, V5E02, V5E28, and V6G21.

19) SSMEPF 15-Ton Bridge Cranes in SSME Work Stand Area-SSME rotating, V6G21.

HAZARD CAUSE:

1. (CONTROLLED/CATASTROPHIC/IMPROBABLE) - Failure of lifting devices and/or associated equipment which could result in dropping a load while personnel are performing work underneath.

HAZARD EFFECTS :

Personnel injury and/or loss of life.

ENGINEERING / SAFETY REQUIREMENTS :

A. Occupational Safety and Health Administration (OSHA), 29 CFR 1910, Occupational Safety and Health Standards, 1989:

   a. 1910.179(n)(3)(vi), Overhead and Gantry Cranes, "The employer shall require that the operator avoid carrying loads over people."

   b. 1910.180(h)(3)(vi), Crawler Locomotive and Truck Cranes, "The operator should avoid carrying loads over people."

B. American Standards Institute (ANSI):

   a. ANSI B30.2-1990, 2-3.2.3(e), Overhead and Gantry Cranes, "The operator should avoid carrying loads over people."

   b. ANSI B30.5-1989, 5-3.2.1.4(e), Mobile and Locomotive Cranes, "The operator should avoid carrying loads over people."

C. NSS/GO-1740.9B, NASA Safety Standard for Lifting Devices and Equipment, November 1991:

   a. Chapter 2, Overhead Cranes, 206(21), "Personnel shall not be located under suspended or moving loads unless the operation adheres to the OSHA-approved NASA Alternate Standard for Suspended Load Operations."

   b. Chapter 3, Mobile Cranes and Derricks, 306(22), personnel shall not be located under suspended loads unless the operation adheres to the OSHA-approved NASA Alternate Standard for Suspended Load Operations."

c. Appendix B - "NASA Alternate Safety Standard for Suspended Load Operations."

D. GSOP 5400, USA Ground Safety Operating Procedures, 2.36, "A load will not be lifted, suspended, or transported over personnel."

E. KHB 1710.2C Kennedy Space Center Safety Practices Handbook.
a. Annex G 1.d "Suspended Load Operation Analysis/Approval (SLOAA)."

OMRSD REQUIREMENTS :

OMRSD	TITLE

File VI, Vol. 1, B/L 237.00, G24GHAMA0.084 - MDD Hoist Rated Load Test (DFRC) - Performs an annual rated load test and verifies the load is held without drift. Performs an operational test of the hoists and verifies the emergency brake controls operate as designed.

File VI, Vol. 1, B/L 237.00, G08FHAMJ0.081 - 50-Ton Hoist Rated Load Test - Verifies the annual rated load test on the 50-Ton forward, aft port, and aft starboard hoists.

File VI, Vol. 1, B/L 242.00, GABFHAEA0.001 - Simulator Assembly Rated Load Test - Performs an annual rated load test and verifies the load is held without drift.

File VI, Vol. 1, B/L 242.00, GAWFHAEA0.001 - Simulator Assembly Rated Load Test - Performs an annual rated load test and verifies the load is held without drift.

File VI, Vol. 1, B/L 242.00, GGDFHAEA0.001 - Simulator Assembly Rated Load Test - Performs an annual rated load test and verifies the load is held without drift.

File VI, Vol. 1, B/L 510.00, GHEGKRM00.001, - 140T Mobile Crane Rated Load Test - Verifies the rated load certification is valid prior to use.

File VI, Vol.. 1, B/L 330.00, G99GKRLA0.002 - 40 Ton Mobile Crane Rated Load Test - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and winch brakes independently holds the rated load.

File VI, Vol. 1, B/L 330.00, G99GKRLB0.001 - 250 Ton Mobile Crane Rated Load Test - Performs an annual rated load test and verifies the load is held without drift.

File VI, Vol. 1, B/L 380.00, GABFCRA0.010 - 30 Ton Bridge Crane Brake Test HB-1 - Performs a brake load test to assure the band brake, mechanical load brake, and electric brake independently holds the rated load.

File VI, Vol. 1, B/L 380.00, GAWFCRFA0.010 - 30 Ton Bridge Crane Brake Test HB-2 - Performs a brake load test to assure the band brake, mechanical load brake, and electric brake independently holds the rated load.

File VI, Vol. 1, B/L 380.00, GGDFCRFN0.002 - 30 Ton Bridge Crane Load Path Test HB-3 - Performs a crane mechanical load path test for the north and south load paths to assure that each load path independently holds the rated load.

File VI, Vol. 1, B/L 389.00, G20FCRVC4.001 - 325-T #1 Main hoist Operational Test - Performs an annual operational test of the main hoist and verifies the east and west brake independently holds the rated load.

File VI, Vol. 1, B/L 389.00, G20FCRVC4.002 - 325/50-T #1 Aux Hoist Operational Test - Performs annual operational test of the 50-Ton Auxiliary Hoist and verifies the east and west brakes independently hold the rated load.

File VI, Vol. 1, B/L 389.00, G20FCRVC5.001 - 325-T #2 Main Hoist Operational Test - Performs an annual operational test of the main hoist and verifies the east and west brakes independently hold the rated load.

File VI, Vol. 1, B/L 389.00, G20FCRVC5.002 - 325/50-T #2 Aux Hoist Operational Test - Performs an annual operational test of the 50-Ton Auxiliary Hoist and verifies the east and west brakes independently hold the rated load.

File VI, Vol. 1, B/L 389.00, GTAFCRVD0.002 - 175-Ton ridge Crane Brake Test - Performs an annual brake load test to assure the holding brakes independently hold the rated load.

File VI, Vol. 1, B/L 389.00, GTAFCRVD0.026 - 175-Ton Bridge Crane Ops Test - Performs an annual operational test to verify the main hoist, auxiliary hoist, bridge, and trolley controls operate as designed.

File VI, Vol. 1, B/L 389.00, GTAFCRVD0.027 - 175 Ton Bridge Crane Ammeter S/O Point - Verifies the console ammeter switch-over point operates as designed.

File VI, Vol. 1, B/L 389.00, GVBFCRVC0.002 - 250-Ton Bridge Crane No. 1 Brake Test - Performs an annual test of the holding brakes to assure each brake independently holds the rated load.

File VI, Vol. 1, B/L 389.00, GVBFCRVC0.026 - 250-Ton Bridge Crane No. 1 Ops Test - Performs an annual operational test to verify the main hoist and main hoist swivel operate as designed.

File VI, Vol. 1, B/L 389.00, GVBFCRVC0.027 - 250-T Bridge Crane No. 1 S/O Point - Verifies the console ammeter switch-over point operates as designed.

File VI Vol. 1, B/L 389.00, GVBFCRVC0.029 - 250 Ton Crane No. 1 Bridge and Trolley Ops Test - performs an annual operational test of the bridge and trolley in all directions.

File VI, Vol.1, B/L 389.00, GVDFCRVC0.002 - 250-Ton Bridge Crane No. 2 Brake Test - Performs an annual test of the holding brakes to assure each brake independently holds the rated load.

File VI, Vol. 1, B/L 389.00, GVDFCRVC0.026 - 250-Ton Bridge Crane No. 2 Ops Test - performs an annual operational test to verify the main hoist swivel operates as designed.

File VI, Vol. 1, B/L 389.00, GVDFCRV0.027 - 250-T Bridge Crane No. 2 S/O Point - Verifies the console ammeter switch-over point operates as designed.

File VI, Vol. 1, B/L 389.00, GVDFCRVC0.029 - 250 Ton Crane No. 2 Bridge and Trolley Ops Test - Performs an annual operational test of the bridge and trolley in all directions.

File VI, Vol. 1, B/L 389.00, GVXFCRVA1.003 - 10-Ton Crane rated Load Test (Cell 1) - Performs an annual rated load test and verifies the rated load is held without drift. Verifies the motor brake and load brake independently holds the rated load.

File VI, Vol. 1, B/L 389.00, GVXFCRVA2.004 - 10-Ton Crane Rated Load Test (Cell 2) - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and hoist down controls operate as designed.

File VI, Vol. 1, B/L 400.15, GBDFCRKA0.030 - 200-T Crane No. 1 (West) Load/Oper Test - Verifies the annual rated load test and operational test is current.

File VI, Vol. 1, B/L 400.15, GBDFCRKB0.031 - 200-T Crane No. 2 (East) Load/Oper Test - Verifies the annual rated load test and operational test is current.

File VI, Vol. 1, B/L 422.00, GRUFHTRA0.010 - Pad A 90-Ton Hoist Rated Load Test - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and the band brake independently holds the rated load.

File VI, Vol. 1, B/L 422.00, GRWFHTRA0.005 - Pad B 90-Ton Hoist Rated Load Test - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and the band brake independently holds the rated load.

File VI, Vol. 1, B/L 238.00, G17FHTD00.054 - MDD Hoist Rated Load Test (SLF) - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and the emergency brake controls operate as designed.

File VI, Vol. 1, B/L 510.00, G99GKRG12.004 - 35 Ton Mobile Crane Rated Load Test - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and verifies boom extends and retracts, outriggers extend and retract, and rated load rotates side to side about base.

File VI, Vol. 1, B/L 422.00, GRUFHRY0.005 - Pad A 10 Ton CAP Hoist Rated Load Test - performs a rated load test for the RSS 10 Ton Clean Access Hoists. Verifies the rated load is raised and held without drift.

File VI, Vol. 1, B/L 036.00, G29FHAB50.001 - SSMEPF 10 -Ton Crane Rated Load Test - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and the motor brake and drum brake independently holds the rated load. Functional checkout of all controls in all modes produces expected results.

File VI, Vol. 1, B/L 036.00, G29FHAB60.001 - SSMEPF 15 -Ton Crane Rated Load Test - Performs an annual rated load test and operational test. Verifies the rated load is held without drift and the motor brake and drum brake independently holds the rated load. Functional checkout of all controls in all modes produces expected results.

LAUNCH COMMIT CRITERIA :

None.

DETAILED ELIMINATION / CONTROL / ACCEPTED RISK RATIONALE :

Possible procedure / design options have been investigated to determine if work can be accomplished without personnel working under a suspended load for each operation. Secondary support system (i.e., equipment designed to assume support of (catch) the load preventing injury to personnel should the hoist / crane fail) have been evaluated and used whenever possible. For those operations which require personnel to perform work beneath suspended loads, a KSC Suspended Load Operation Analysis has been processed and approved by SFOC and NASA management. Rationale for reducing the risk to personnel is presented in each of the analyses.

Each lifting device has been thoroughly analyzed in accordance with NSTS 22206, "Requirements for Preparation and Approval of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)" and NSTS 22254, "Methodology for Conduct of Space Shuttle Program Hazard Analyses", and documented in a System Assurance Analysis (SAA). Each SAA includes a FMEA/CIL and hazard analysis. The FMEA/CIL identifies critical items within

each system and their failure effects and presents rationale for accepting the risk of critical items based upon design information, failure history and operational controls. In addition, the hazard analysis ensures lifting devices meet applicable safety standards, identifies hazardous conditions which may be present and verifies appropriate controls are in place to reduce the risk to personnel. These in-depth system analyses of the lifting devices ensure that safety and operational personnel, as well as KSC management, are aware that all potential hazards have been identified and controls have been established to reduce the risk of working under a suspended load to an acceptable level.

NSS/GO-1740.9 establishes NASA's minimum safety requirements for the design, testing, inspection, personnel certification/recertification, maintenance, and use of overhead and gantry cranes (including top running monorail, underhung, and jib cranes), mobile cranes, derricks, hoists, and special hoist supported personnel lifting devices. It also addressees minimum requirements for the testing, inspection, and use of hydra-sets, hooks, and slings.

The NASA Alternate Safety Standard for Suspended Load Operations establishes NASA's minimum standards for working under suspended loads. This standard is an alternate to 29 CFR 1910.179(n)(3)(vi) and 29 CFR 1910.180 (h)(3)(vi).

The NSS/GO-1740.9 and the Alternate Standard require that:

1. Steps shall be taken to limit the number of personnel working under a load suspended from a crane / hoist. Only those essential personnel absolutely necessary to perform the operation will be allowed to work in the safety controlled area.

2. Steps shall be taken to ensure that personnel do not remain under the load any longer than necessary to complete the work.

3. Prior to the suspended load operation, a meeting with the crane/hoist operator(s), signal person(s), and the person(s) who will work under the load, and the person responsible for the task shall be held to plan and review the approved operational procedures that will be followed, including procedures for entering and leaving the safety controlled area.

4. Communications, (voice, radio, hard wired, or visual) between the operator(s), signal person(s), and the person(s) working under the load shall be maintained. Upon communication loss, operations shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

5. Personnel working beneath the load shall remain in continuous sight of the operator(s), and/or signal person(s).

6. A proofload test at 1.25 times the rated load and an operational test shall be performed on all new or extensively repaired, extensively modified, or altered cranes and hoists (1.10 times for mobile cranes).

7. Each crane shall undergo a rated load test and an operational test every four years. Critical cranes shall be load tested annually. Cranes used infrequently for critical lifts shall be load tested before the critical lift if it has been more than a year since the last test.

8. Daily and periodic inspections will be performed for all cranes. Cranes idle for more than one month shall be inspected prior to first use in accordance with NSS/GO-1740.9.

9. Daily inspections include: a check of functional operating and control mechanisms for maladjustments, excessive wear and contamination; a visual inspection of fluid system components for deterioration and leaks; and a

visual inspection for the crane components (e.g., hook, ropes, etc.) for damage or excessive wear.

10. Periodic inspections per NSS/GO-1740.9 include inspections for: worn, cracked, deformed, corroded, or contaminated crane components (use of nondestructive evaluation to be utilized as needed or required by NSS/GO-1740.9); worn brake and clutch system components; and abnormal performance/malfunction of power plant(s), safety devices, load/other indicators, brakes, steering, and locking devices.

11. Lifting equipment shall be verified to be within valid load test certification prior to use per NSS/GO 1740.9.

12. Operational checks will be performed prior to lifting operations to assure proper control response in all modes.

13. Cranes are operated only by trained and certified operators per KMI 6430.4, Examination and Licensing of KSC Facility Crane Operators, or KMI 6730.3, Examination and Licensing of KSC Special or Heavy Equipment Operators. Crane operators are required to carry a valid operators license with them at all times while operating a crane.

Those permanent operations listed below under Verification Methods are suspended load operations which cannot be eliminated by design changes. All have been closely examined and determined to be in compliance with the NASA Alternate Safety Standard.

SUMMARY ACCEPTANCE RATIONALE :

Possible procedure/design options have been investigated to determine if work can be accomplished without personnel working under a suspended load for each operation. Secondary support systems (i.e., equipment designed to assume support of (catch) the load preventing injury to personnel should the hoist/crane fail) have been evaluated and used whenever possible. For those operations which require personnel to perform work beneath suspended loads, a Suspended Load Operation Analysis/Approval Report has been processed and approved. Design changes have been implemented, where feasible, to eliminate or mitigate suspended load operations. The NASA Alternate Safety Standard for Suspended Load Operations establishes NASA's minimum standards for working under suspended loads. Those permanent suspended load operations which cannot be eliminated by design changes have been closely examined and determined to be in compliance with the NASA Alternate Safety Standard.

OMI / TPS / WAD VERIFICATION :

The following NASA Suspended Load Operation Analysis/Approval (SLOA/A) Reports have been approved for operations which require personnel to perform work beneath suspended loads. Each report contains a description of the suspended load task(s) and lists the supporting documents. The reports describe how the task(s) complies with the NASA Alternate Safety Standard for Suspended Load Operations.

SLOA/A #	OMI	DESCRIPTION
1991-001	S0004	Orbiter Mate to the External Tank
1991-002	S0030	Orbiter Demate from the External Tank
1991-003	S5022	Orbiter Mate to the Shuttle Carrier Aircraft (SCA) at Dryden Flight Research Center (DFRC)
1991-004	S5054	Orbiter Mate to the Shuttle Carrier Aircraft (SCA) at Contingency Landing Site
1991-005	S5001	Orbiter Demate at the Shuttle Landing Facility (SLF), KSC

1991-006	S5041	Orbiter Mate to the Shuttle Carrier Aircraft (SCA) at KSC
1991-007	S5045	Orbiter Mate to the Shuttle Carrier Aircraft (SCA) at the Rockwell Palmdale Facility
1991-008	V5112.007	Orbiter Towing Operations-Orbiter Processing Facility (OPF) to Mate/Demate Device (MDD)
	.008	-Vehicle Assembly Building (VAB) High Bay II to Mate/Demate Device (MDD)
	.009	-Mate/Demate Device (MDD) to Orbiter Processing Facility (OPF)
	.013	-Vehicle Assembly Building (VAB) Transfer Aisle to Mate/Demate Device (MDD)
	.014	-Mate/Demate Device (MDD) to Vehicle Assembly Building (VAB) High Bay II
	.015	-Mate/Demate Device (MDD) to Vehicle Assembly Building (VAB) Transfer Aisle
1991-009	B5141	Solid Rocket Booster (SRB) Destack Operations , VAB
1991-010	B5143	Aft Booster Disassembly Operations, RPSF
1991-011	B5303	Stacking and Alignment Operations, VAB
1991-012	B5309	Aft Booster Assembly Operations, RPSF
1991-013	T5002.015	External Tank (ET) Mate to External Tank Transporter
1991-015	T5002.012	External Tank (ET) Off-Load from the Transporter
1991-016	V5087	Space Shuttle Main Engine (SSME) Rotation, SSME Move Vertical to Vertical, and Rotating Sling Functional Checkout
1991-017	V5E02	SSME High Pressure Oxidizer Turbo Pump Removal/Installation
	V5E63	SSME Alternate High Pressure Oxidizer Turbo Pump Removal/Installation
1991-018	V5E28.001	Engine Powerhead/Nozzle Separation in the Vehicle Assembly Building (VAB) Engine Shop and SSMEPF
1991-019	V6G21	Preventive Maintenance/SSME Rotating Sling Maintenance
1991-020	V5136	Operate/Utilize the Clean Access Platform (CAP) at LC-39 (Pad A/B)

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1991-021	E5010	Rotate the Payload Canister at the Vehicle Assembly Building (VAB)
1991-022	E5026	Hoisting and Lowering of Payload Canister at LC-39 Pad A/B
1991-023	E5005	Install/Remove Keel Covers, Guide Keel Trunnions Into Keel Latches, Attach MHC Shoes to MHC, Install MHC Shoes onto MHC Spindles, Installation of Spacehab Transfer Tunnel
1991-034	V9023.001	Operate, Inspect, Adjust and Repair the Orbiter Payload Bay Doors at the Orbiter Processing Facility (OPF)
1992-003	S5046	Orbiter Demate at the Orbiter Lifting Facility (OLF), Rockwell Palmdale Plant
1992-004	S0028	Orbiter Tow/Spot Into/Out of the Mate/Demate Device at the Shuttle Landing Facility (SLF), KSC
1993-005	S0004	Orbiter Mate to External Tank (ET) (325-Ton Crane)
1993-006	S0030	Orbiter Demate from the External tank (ET) (325-Ton Crane)
1993-007	B5141	Solid Rocket Booster Destack Operations, VAB (325-Ton Crane)
1993-008	B5303	Stacking and Alignment Operations, VAB (325-Ton Crane)
1993-009	T5002.015	External Tank (ET) Mate to External Tank Transporter (325-Ton Crane)
1993-010	T5002.012	External Tank (ET) Off-Load from the Transporter (325-Ton Crane)
1998-001	V9023.001	Payload Bay Door Lightweight Strongback Installation/Removal

ESR :

ECP1221, K14022, K14593, K14594, K14595, K14596, K14597, K14598, K14599, K14600, K14601, K14602, K14603, MCR16608, MCR21013

SAA REFERENCES :

SAA	TITLE
SAA09FY12-005	250-Ton Bridge Crane, VAB
SAA09FY12-006	175-Ton Bridge Crane, VAB
SAA09FY112-002	200-Ton Bridge Crane RPSF
SAA09FY120-001	325-Ton Bridge Cranes at the VAB
SAA29OM01-001	Mate/Demate Device KSC/DFRF
SAA09FY091-001	30-Ton Bridge Cranes OPF HB-1 and 2
SAA09FY091-007	30-Ton Bridge Crane OPF HB-3
SAA09FTA3-001	Clean Access Platform Pads A
SAA09FT01-004	250-Ton HC-268 Truck Crane
SAA09FT01-006	Linkbelt 40 Ton Mobile Crane HSP 8040, KSC
SAA09FT01-009	250-Ton Pettibone Mobile Crane, LOA

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SAA09FY121-002 10-Ton Bridge Crane VAB Cell, 1,2, and 4
SAA09FTA3-004 90-Ton Hoist, PAD A
SAA09FTB3-003 90-Ton Hoist, PAD B
SAA09FTP3-006 Horizontal Zero Gravity Simulator, OPF
SAA29CL01-025 Orbiter Lifting Frame, Palmdale
SAA09CR00-001 10 & 15-Ton Bridge Crane SSMEPF

FMEA/CIL REFERENCES :

SAA09CR00-001:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Load hold/halt drum brake	2	09CR00-001.001	Fails to engage	1R
Motor brake	2	09CR00-001.002	Fails to engage	1R
Programmable Logic Controller	2	09CR00-001.003	Unsolicited command.	1
Gearbox	2	09CR00-001.004	Gear disengagement	1R

SAA09FT01-004:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Bumper Jack Cylinder	1	09FT01-004.001	Piston head seal failure (internal leakage).	1R
Bumper Jack Cylinder		09FT01-004.002	Rod seal failure (external leakage).	1R
Front Bumper Jack Lock Valve		09FT01-004.003	Fails open (rod side).	1R
Front Bumper Jack Lock Valve	1	09FT01-004.004	Relieves prematurely.	1R
Lock valve	4	09FT01-004.005	Fails open (rod side).	1R
Lock valve		09FT01-004.006	Relieves prematurely.	1R
Outrigger Jack Cylinder Assembly	4	09FT01-004.007	Piston head seal failure (internal leakage).	1R
Outrigger Jack Cylinder Assembly		09FT01-004.008	Rod seal failure (external leakage).	1R

SAA09FT01-006:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Reduction Unit Assembly	1	09FT01-006.001	Gears disengage.	1
Winch Brake Assembly	1	09FT01-006.002	Brake slips or fails to engage.	1

SAA09FT01-009:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Pilot Check Valve	4	09FT01-009.001	Fails open.	1R

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Winch Gear Case Assembly	1	09FT01-009.002	Gears disengage.	1
Crowd Control Valve	1	09FT01-009.004	Fails open.	1R
Outrigger Control Valve	4	09FT01-009.005	Fails open.	1R
Double Over Center Valve	1	09FT01-009.006	Fails open.	1R

SAA09FTA3-001:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Speed Reducer	2	09FTA3-001.001	Gear disengagement.	1R

SAA09FTA3-004:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Geared Coupling	1	09FTA3-004.001	Mechanical failure.	1R
Gear Box	1	09FTA3-004.002	Gear disengagement.	1R
Drum Band Brake Assembly	1	09FTA3-004.003	Fails to engage and hold.	1R

SAA09FTB3-003:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Gear Reducer	1	09FTB3-003.001	Gear disengagement.	1R
Band Brake Assembly	1	09FTB3-003.002	Brake slips of fails to set.	1R

SAA09FY091-001:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Speed Reducer (Main Hoist)	2	09FY091-001.001	Gear disengagement.	1R
Solenoid Actuated Band Brake	2	09FY091-001.002	Fails to engage.	1R

SAA09FY091-007:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Brake Wheel	2	09FY091-007.001	Key disengages.	1R
Brake	2	09FY091-007.002	Fails to engage.	1R
Coupling	2	09FY091-007.003	Key disengages	1R
LH Reducer	2	09FY091-007.004	Gear disengages.	1R
Coupling	2	09FY091-007.005	Key disengages.	1R
Coupling	2	09FY091-007.006	Key disengages.	1R
RH Reducer	2	09FY091-007.007	Gear disengages.	1R
Coupling	2	09FY091-007.008	Key disengages.	1R

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Brake	2	09FY091-007.009	Fails to engage.	1R
Brake Wheel	2	09FY091-007.010	Key disengages.	1R

SAA09FY112-002:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Hoist Gear Case	1	09FY112-002.001	Gear disengagement.	1R
Emergency Drum Brake	3	09FY112-002.003	Fails to engage.	1R

SAA09FY12-005:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Motor - Generator Set, Main Hoist	2	09FY12-005.004	No output	1
Potentiometer	2	09FY12-005.022	Fail open.	1R
Motor - Main Hoist	4	09FY12-005.032	Open armature winding	1
Generator Field DC Input Controller	2	09FY12-005.079	High ouput (not inverted).	1R
Generator Field DC Input Controller	2	09FY12-005.080	High ouput (inverted).	1R
Generator Field DC Input Controller	2	09FY12-005.081	High ouput (not inverted).	1R
Generator Field DC Input Controller	2	09FY12-005.082	High ouput (inverted).	1R
Generator Field DC Input Controller	2	09FY12-005.083	High ouput (not inverted).	1R
Generator Field DC Input Controller	2	09FY12-005.084	High ouput (inverted).	1R
Potentiometer	2	09FY12-005.096	Fails open.	1R
Potentiometer	2	09FY12-005.097	Fail open.	1R
Relay, Main Hoist	2	09FY12-005.098	Fails deactivated	1
Relay	2	09FY12-005.099	N.O. contact fails open.	1
Relay, Main Hoist	2	09FY12-005.100	Fails deactivated.	1
Relay, Main Hoist	2	09FY12-005.101	N.O. contact fails open.	1
Relay, Main Hoist	2	09FY12-005.102	N.O. contact fails open.	1
Relay - Main Hoist	2	09FY12-005.103	N. C. contact fails open	1
Transformer	2	09FY12-005.104	Winding fails open or shorted.	1
Circuit Breaker	2	09FY12-005.105	Contact fails open.	1

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Gear Train, Main Hoist	2	09FY12-005.112	Gear disengagement.	1R
Relay	2	09FY12-005.120	Fails deactivated (coil fails open).	1R
Relay	2	09FY12-005.121	N.C. contact fails closed.	1R
Relay	2	09FY12-005.122	Coil fails to deenergize.	1R
Relay	2	09FY12-005.123	N.O. contact fails closed.	1R
Rectifier	2	09FY12-005.124	Diode fails open/shorted.	1R
Relay	2	09FY12-005.125	N.O. contact fails closed.	1R
Relay	2	09FY12-005.126	N.O. contact fails closed.	1R
Relay	2	09FY12-005.127	Coil fails to deenergize.	1R
Relay	2	09FY12-005.128	N.O. contact fails closed.	1R
Rectifier	2	09FY12-005.129	Diode fails open/shorted.	1R
Relay	2	09FY12-005.130	N.O. contact fails closed.	1R
Relay	2	09FY12-005.131	Coil fails to deenergize.	1R
Relay	2	09FY12-005.132	N.O. Contact fails closed.	1R
Rectifier	2	09FY12-005.133	Diode fails open/shorted.	1R
Relay	2	09FY12-005.134	N.O. contact fails closed.	1R

SAA09FY12-006:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Motor - Generator Set, Main Hoist	1	09FY12-006.004	No ouput.	1
DC Motor, Main Hoist	2	09FY12-006.032	Open armature winding	1
Gear Train, Main Hoist	1	09FY12-006.091	Gear disengagement.	1R
Gear Train, Main Hoist	1	09FY12-006.092	Gear disengagement	1R
Flex Coupling, Main Hoist	1	09FY12-006.093	Disengages.	1R
Flex Coupling, Main Hoist	1	09FY12-006.094	Disengages.	1R

SAA09FY120-001:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Main Hoist Gear Reducer	2	09FY120-001.001	Gear disengages.	1R
Main Hoist Pinion Gear Coupling	2	09FY120-001.002	Key disengages.	1R
Main Hoist Brake Wheel	2	09FY120-001.003	Key disengages.	1R
Main Hoist Electric Brake	2	09FY120-001.004	Stuck mechanism, worn or glazed shoes.	1R

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Main Hoist Pinion Gear	2	09FY120-001.005	Gear disengages.	1R
Main Hoist Drum Gear	2	09FY120-001.006	Gear disengages.	1R
Auxiliary Hoist Gear Reducer	2	09FY120-001.007	Gear disengages.	1R
Auxiliary Hoist Pinion Gear Coupling	2	09FY120-001.008	Key disengages.	1R
Auxiliary Hoist Brake Wheel	2	09FY120-001.009	Key disengages.	1R
Auxiliary Hoist Electric Brake	2	09FY120-001.010	Stuck mechanism, worn or glazed shoes.	1R
Auxiliary Hoist Pinion Gear	2	09FY120-001.011	Gear disengages.	1R
Auxiliary Hoist Drum Gear	2	09FY120-001.012	Gear disengages.	1R

SAA09FY121-002:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Hoist Gearbox Assembly	2	09FY121-002.001	Gear disengagement.	1
Motor Brake	2	09FY121-002.003	Fails to set.	1R
Hoist Gearbox (Load Brake)	2	09FY121-002.004	Fails to set.	1R

SAA29CL01-025:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Gear Reducer 1	3	29CL01-025.001	Fails to engage.	1R
Gear Reducer 2	3	29CL01-025.002	Fails to engage.	1R
Drum Brake	3	29CL01-025.003	Fails to engage.	1R

SAA29OM01-001:

Critical Item Name	Qty	FMEA/CIL Number	Critical Failure Mode	Crit Cat
Drum Speed Reducer	2	29OM01-001.001	Disengages.	1R
Emergency brake solenoid	2	29OM01-001.002	Coil fails open.	1R
Time Delay Relay and/or Contacts	2	29OM01-001.003	Fails open.	1R
Rectifier Network	2	29OM01-001.004	No ouput.	1R
Fuse 5A	2	29OM01-001.005	Fails open.	1R

BACKGROUND :

ECP1221 - Suspended Load Abatement modification and Bearing Retention System Change - Completed per CCBD S-1221-G on 09/22/93.

ESR K14022 - Crane/Hoist Design Discrepancies - Completed per CCBD E-K14022-G on 02/17/93.

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ESR K14593 - Modify ET Forward Sling and ET Storage/Checkout Cells - Completed per CCBD SSP07788 on 05/21/96.

ESR K14594 - GSE Design Plan for Orbiter Radiator Removal and Installation Operation - Completed per CCBD SSP07788 on 05/21/96.

ESR K14595 - SRB Rotation, Processing, and Surge Facility (RPSF) Operations - Completed per CCBD SSP07788 on 05/21/96.

ESR K14596 - Stacking and Alignment Operations - Completed per CCBD SSP07788 on 05/21/96.

ESR K14597 - Aft Booster Assembly - Completed per CCBD SSP07788 on 05/21/96.

ESR K14598 - SPC Abatement Plan for OMIs V5001, V5041, V5042, and S5022 - Completed per CBD SSP07788 on 05/21/96.

ESR K14599 - Suspended Load Abatement for Orbiter/SCA Mate DFRF (CLS) - Disapproved per NASA SLOA/A SLO-KSC-1991-003 and 004.

ESR K14600 - Suspended Load Abatement for Orbiter/SCA Mate DFRF (SLS-1) - Disapproved per NASA SLOA/A SLO-KSC-1991-003 and 004.

ESR K14601 - SPC Abatement Plan for OMI V1101 and V2105 - Completed per CCBD KSOG-00283 on 05/21/96.

ESR K14602 - Modification of Gimbal Assembly of HPOTP for Suspended Loads - Completed per CCBD SSP07788 on 05/21/96.

ESR K14603 - Fabrication of HPOTP Dolly for Suspended Load Abatement - Completed per CCBD SSP07788 on 05/21/96.

MCR 16608 - Design Changes for OSHA Abatement - Completed per CCBD M-16608-G on 02/19/93.

MCR 21013 - Modification to the Support Fixture PLB Radiator, GSE Model H70-0651 and A70-0608 - Completed per CCBD M-21013 on 02/11/93.

INTERFACES :

None.

STATUS OF OPEN WORK :

None.

REMARKS :

6/22/88 - SSRP changed to Industrial. This HR was neither approved nor disapproved with CR 50404N, but left to KSC to control as an Industrial hazard. This hazard will be maintained in the KSC Hazard Data Base. Status changed to closed. "Damage to flight hardware" deleted from hazard effect data element.

2/17/89 - Added O-ring inspectoscope operation and references to cranes and OMIs used for Orbiter/SCA mate/demate at DFRF/KSC/CLS. Also added reference to hazard report RT-ENG-1027, which covers the 250-ton VAB crane single failure points.

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01/14/92 - Added ESRs K14022, K14593, K14594, K14595, K14596, K14597, K14598, K14599, K14600, K14601, K14602, K14603.

12/04/92 - Added ESRs ECP 1221, MCR 16608, MCR 21013.

01/30/95 - Periodic update performed. Hazard closure classification changed to controlled. This hazard report previously approved by the KSC Level III CCB on 06/07/88.

10/17/97 - Hazard number changed from SPC-001-95 to LL-0012. Team/Log number changed from SPC/1 to LL/12. Administrative changes were made to the configuration and hazard analysis data. Added 40-Ton Link Belt Mobile Crane (B/L 330.00, 35-Ton Pettibone Mobile Crane (B/L 510.00), and 140-Ton Manitowoc Mobile Crane (B/L 510.00). Added closure of ESRs to Background field.

6/29/98 - Added 10 & 15 Ton Bridge Crane (B/L 036.00) at the SSMEPF. Hazard report previously approved by KSC Level III CCB on 1/13/98.

9/3/98 - Update performed as a result of crane usage changes in the VAB checkout cell 4 and SSME main assembly area. Hazard report previously approved by KSC Level III CCB on 08/06/98.